JPRS-UMM-85-013

16 October 1985

USSR Report

MACHINE TOOLS AND METALWORKING EQUIPMENT

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INDUSTRY PLANNING AND ECONOMICS

MODERNIZATION OF ARMENIAN MACHINE TOOL PRODUCTION URGED

Yerevan KOMMUNIST in Russian 20 Jun 85 p 2

[Article by G. Yeritsyan, general director of the Charentsavan Machine-Tool-making Production Association and Chairman of the Council of the Republic's Machine-Tool and Toolmaking Enterprises Directors: "The Machine Tool--Today and Tomorrow"; passages enclosed in slantlines printed in boldface]

[Text] M. S. Gorbachev's report at the recently held CPSU Central Committee Conference on Problems of Accelerating Scientific and Technical Progress cannot leave one manager indifferent. The key role of machinebuilding and the necessity for increasing its growth rate 1.5-2 fold during the 12th Five-Year Plan was especially emphasized. The party established a task of special importance--to arrange for the large-scale manufacture of new-generation equipment capable of yielding a severalfold rise in labor productivity and of paving the way for automation of all stages of the production process. In this connection, I want to single out certain considerations in developing the republic's machine-toolmaking industry.

In Armenia this branch is represented by six machine-tool plants and four toolmaking and six specialized enterprises for producing outfitting equipment and blanks. During the 11th Five-Year Plan, production area and capacity were expanded, and the range of articles produced was increased. It should be noted, at the same time, that a large number of articles that we produce lag behind modern requirements in their technical and economic indicators and in the quality of their manufacture.

/The lag in machine-tool output is heightened by the excessively slow mastery of new items./ It took the Yerevan Machine-Tool Association, for example, more than 10 years to master serial production of the model 16B16 machine tool from a new assortment of lathes (they were developed in 1967-1971). At the Oktemberyan Machine-Toolmaking Plant, a test model of a model 2532 beam drill was turned over to the state commission in 1981, but serial production began only this year. On the average, /the "development-to-mastery" cycle is extended by 5-7 years at our plants instead of the maximum period of 2 years that is allowed./

The April 1985 CPSU Central Committee Plenum emphasized that industry needs revolutionary feats and conversion to basically new industrial systems and to equipment that yields the highest productivity. Unfortunately, it must be noted that our machine-tool plant workers' plans still have not been aimed

at solving this problem. The republic plans to master 26 new models of machine tools, 6 of them NC machine tools, during the 12th Five-Year Plan. Such a developmental pace cannot satisfy anyone.

Without pretending to be comprehensive, I would like to direct attention to a number of problems which, if not solved, will not allow the lag in the technical level of the republic's machinebuilding behind modern requirements to be overcome in the speediest fashion. It is perfectly obvious that /the main task for all machine-toolmaking plants is the same: to develop and introduce into serial production as quickly as possible machining modules--multiple-operation NC machine tools, equipped with accessories for replacing an unlimited number of tools and blanks, which can be incorporated into GPS's [flexible production systems]./ It should be emphasized that Armenia's machine-tool plants must solve this problem while continuing to produce general-purpose machine tools, since practically all of them have been named by Minstankoprom [Ministry of Instrument Making, Automation Equipment and Control Systems] as enterprises intended for covering the country's requirements for general-purpose equipment.

Effective results in the area of the development and introduction into production of machining modules under the given circumstances of the republic's machine-toolmakers can be achieved only by amalgamated efforts. In this case, /not a formalistic but a businesslike creative collaboration among machine-toolmaking plants, with enterprises of the electronics, electrical-equipment and instrumentmaking industries, and with sector, academic and educational institutes is necessary./

The modern highly productive machine-tool module is a machine based upon a synthesis of three complicated systems: precision mechanics, hydraulics and electronics, each of which is broken down into subsystems which include hundreds of outfitting items and thousands of parts.

The republic's machine-toolmakers are compelled to take steps themselves in the area of creating the necessary outfitting items. Thus, at the Charentsvan SPO [Machine-Toolmaking Production Association] the series production of outfitted electric feed drives and special flexible couplings is being organized. The volume of these items produced will enable not only the republic's but also the whole Transcaucasus region's requirements to be covered.

/Armenia, which has a developed electronics industry, can make a considerable contribution to developing the country's machine-toolmaking by taking upon itself the task of developing and producing multiple-coordinate NC systems, the output of which Minpribor is delaying each year./ YerNIIMM [Yerevan Scientific-Research Institute for Mathematics and Mechanics] specialists, who have solved much more complicated problems, would be completely capable of developing such systems in a short time and could organize production of them at the Charentsavan SPO, which has gained adequate experience in producing electronics articles for machine-toolmaking.

Experience in the operation of machine tools with a high degree of automation shows that, in order to be able to realize its capabilities, such a machine tool must have a large amount of tooling. Throughout the republic, the cost of all the tooling shipped with machine tools, now averages about 3 percent

of the machine tool's cost, that is, the equipment is delivered practically without tooling and tools.

Meanwhile, there are two toolmaking enterprises in the republic--the Charentsavan Tool PO [Production Association] and the PO Tekhosnastka--whose specialization and capacity permit them to cope completely with this task.

Modern machine-toolmaking makes especially severe demands on personnel. Machining modules belong in the category of science-intensive output. The complexity of the problems that come up during their design and introduction requires the involvement of a large number of highly qualified specialists. Therefore, failure to provide plants with engineering personnel is a serious obstacle in the path to the introduction of highly automated machine tools into the industry. At the Ivanovo SPO the existing design subunit numbers 400 people and still another one is now being established with the same manpower. At the Charentsavan SPO, which is similar, fewer than 50 designers are at work, and each year two or three young engineers are added to them. Indeed, also needed are manufacturing engineers, setting-up operators, middle-level line supervisors, and so on. /The Yerevan Polytechnical Institute, which is basically the republic's only engineering vuz for training specialists in machine toolmaking, should take steps toward satisfying the machine-toolmaking plants requirements more completely./

The republic's machine-toolmaking plants must be reequipped in the shortest possible time, for a substantial portion of their existing equipment is obsolete or worn. /At the Yerevan Milling-Machine Plant, the number of machine tools that have been operating more than 20 years is 38 percent, at the Charentsavan SPO the figure is 20 percent. On the whole, 45 percent of the equipment at the republic's machine-toolmaking plants has been operating more than 10 years, 12 percent more than 20 years./

Reequipping is necessary. But how are we operating existing modern equipment? Poorly. Out of 208 NC machine tools at enterprises, only 162 are in operation, and the shiftwork factor and the load factor for these machine tools are in most cases lower than for general-purpose machine tools. Thus, /at the Yerevan SPO, the workload factor is 0.6, at the milling-machine plant 0.68. The causes of this are: low reliability and poor equipping of the machine tools and a lack of qualified operators./

A lack of intrarepublic cooperation also adversely affects development of the republic's machine-toolmaking plants, since specialized enterprises which produce outfitting products are not oriented to the machine-toolmaking plants' requirements. Thus /both the Stankonormal Plant and the PO gidroprivod send more than two-thirds of their output to enterprises outside the republic, while Armenia's machine-toolmaking plants import the same number of units and hydraulic apparatus./ The situation is the same with Charentsavan's Tsentrolit, which does not provide the Charentsavan SPO with large-dimension castings, so multiple-ton billets are hauled thousands of kilometers.

KOMMUNIST published back in 1982 an article, "The Machine Tool in a Cross-Section of Time," about many of the problems being raised today. Almost 3 years have elapsed but, as they say, things are right where they started.

The program for converting to the output of modern machine tools which meet the spirit of the times should be precisely balanced at all levels. Possibly, considering the special importance of this program to the national economy, a special organ should be formed that will be able to coordinate the work of the machine-toolmakers, the electronics people, Gossnab, republic ministries, vuzes, and branch and academic institutes, as well as other agencies and organizations whose participation is required by the circumstances.

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CSO: 1823/219

INDUSTRY PLANNING AND ECONOMICS

NEW EFFORTS TO INTENSIFY MACHINE TOOL PRODUCTION NOTED

Moscow EKONOMICHESKAYA GAZETA in Russian No 25, Jun 85 p 2

[Article by G. Shutkov, general director, Izhorskiy zavod Production Association: "To the Level of World-Class Quality," "A Strong Impetus to Progress in Science and Technology," "From Participants in CPSU Central Committee Discussion"]

[Text] The key, leading role in carrying through the revolution in science and technology belongs to the machine-building industry. This is the way the party sees things. This imposes upon us machine builders a task of enormous importance—to meet the national economic demand for state-of-the-art machines and equipment in the shortest possible periods of time and to improve the quality and efficiency of the machines we build. The key objective now is to make maximum use of every available means of increasing growth.

The four years of the five-year-plan period have seen no little progress in this direction. Labor productivity within the association is up 24.7 per cent and will increase some 34 per cent for the five-year-plan period overall. But if we look now at the association's machine-building production, we see labor productivity up 45 per cent. Production volume for the five-year period will rise roughly 34.4 per cent, machine-building production by 50 per cent. Production of equipment for atomic power plants is currently up 85 per cent.

At the basis of these consistent rates of growth in production and labor productivity lies the introduction of the fruits of the labors of our scientists and engineers. The years of the Eleventh Five-Year Plan period have seen expenditures in support of advances in science and technology run to 48.4 million rubles, 29 million of which have gone for modernization and reequipment. Practical experience demonstrates how quickly these investments pay for themselves—the economic gain we will derive over the same period will run to some 65 million rubles.

These steps have created a solid foundation for further increases in our rate of growth over the course of the coming five-year-plan period. In view of the high-priority tasks outlined at the meeting, we have decided to focus our efforts primarily upon improvements in production and ways to upgrade our technical production standards.

The Twelfth Five-Year-Plan period will see rates of growth in machine-building production which will be higher than the factory average. With this objective

in view we have taken a number of steps to create workplaces equipped with numerically control machines which will incorporate elements of the flexible automated production facilities.

It is important, however, that we work for much more than simple increases in production volume. We must also strive for improvements in quality, reliability and the entire range of economic engineering indicators overall. For the fact is that we are making machines not for today, but for tomorrow. And the entire association is working today with this objective in view. Let me point out a few examples.

The association has developed a new production technology for fabricating components of equipment for atomic power plants. If, now, we look at another one of our products, large open-pit mining excavators, the objective is to improve these machines to the level of the best models currently on the world market. Improvements in the design of these machines will make it possible, on the one hand, to improve the working environment for the machine operator substantially and, on the other, to extend the operating life of the machine between major repairs.

At the center of efforts to intensify production operations is the question of how we can reduce the level of expenditures required to bring out a new product. Extraordinarily important for our association is the problem of how to reduce the labor-intensity of production operations and our dependence on manual labor and to eliminate superfluous workplaces. The years of the Eleventh-Five-Year-Plan period will see us save the labor of more than 6000 workers and eliminate some 325 inefficient work places. The Twelfth Five-Year-Plan period will see us intensify our efforts in this direction. The simple fact is that we have no alternative because our association is growing and expanding. We are building and modernizing. November 1985 will see us bring our "5000" sheet-rolling mill, the only one of its kind in the country, into operation. The coming five-year-plan, it is being proposed, will call for the construction of the second stage of the mill along with a heat-treatment shop and the first stage of an electric steel melting facility. According to our computations, to bring all these facilities on line will require another 2500 workers. We have set ourselves the objective, however, of foregoing any additions to manpower and achieving all increases in production by increasing labor productivity.

The key difficulty we face in modernizing our production operations, however, is the shortages in equipment, particularly the high-capacity new machines such as the numerically controlled processing centers, which the country is still not manufacturing in sufficient quantities. So the only way of solving the problem in the foreseeable future that we can see is to mechanize production operations through our own efforts and to concentrate production in individual facilities on the basis of more highly developed specialization and improvements in workplace efficiency.

By the end of 1985 we plan to reduce the component of our workers engaged in manual labor to 26.6 per cent and on down to 17 per cent by the end of the Twelfth Five-Year-Plan period. In implementing the "Intensification-90" program, the association will be reducing the labor intensity of production operations at higher rates than ever before. For the present, we have been able to

cap the growth of our machine inventory, and the years immediately ahead will see us begin to reduce it and gradually accelerate the pace at which we can eliminate work places. Over the period 1986-1990 we are expecting to be able to take 1100 units of obsolete equipment out of operation, to include 650 units of metal-cutting machinery. This equipment will be replaced by new, high-capacity machinery which will enable us to increase production with a smaller number of well-equipped work places.

Great potential for accelerating our rate of growth is also to be found in intensified efforts to achieve operational economies. Our production operations are highly energy-intensive, so the question of how we can reduce energy consumption is a particularly important one for us. The association is meeting its targets for reductions in metal, fuel and energy consumption. Over the four years of the Eleventh Five-Year-Plan period, for example, we have saved over 8 million kilowatt-hours of electricity.

Our association is the primary manufacturer of equipment for atomic power plants. The Ministry of Energy is now complaining that we are behind in deliveries of certain individual units of equipment. The months immediately ahead, however, will see us resume a smooth, steady flow of deliveries of equipment for new power plants under construction. We already have all the resources we need for this. A number of planning problems, however, are causing us some difficulty in this connection. USSR Gosplan, unfortunately, has for a long time now been unable to present a firm list of atomic power plant projects for the coming five-year-plan period, to include those scheduled for start-up during the 1986-1987 time frame. One result, as was pointed out at the CPSU Central Committee meeting, has been that we still do not have any firm list of orders for items with long production cycles. So it would be desirable in this instance to reduce the period required for the Ministry of Energy and all the other ministries involved in supplying equipment for these power stations to reach agreement to an absolute minimum. Sometime before the end of 1985 we are going to have to know which units of which atomic power plants are scheduled for start-up in 1988. This program should be firm and subject to no further substantial changes. The discussion of these questions at the meeting will without doubt help speed up the resolution of these problems.

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CSO: 1823/221

INDUSTRY PLANNING AND ECONOMICS

INVESTMENT IN CAPITAL STOCKS, AMORTIZATION RATES REVIEWED

Moscow PLANOVOYE KHOZYAYSTVO in Russian No 7, Jul 85 pp 30-36

[Article by A. Malygin, sector manager of NIEI [Scientific-Research Institute for Economics] under USSR Gosplan and doctor of economic sciences: "Renewal of Fixed Production Capital"]

[Text] It was noted at the April 1985 CPSU Central Committee Plenum that "recently, production equipment has aged greatly and the coefficient of renewal of fixed capital has been reduced. A considerable rise in the coefficient of replacing equipment should be first priority during the 12th Five-Year Plan."[1]

Renewal of the means of labor on a modern technical basis and in accordance with the established optimal service lives thereof is a determining factor in the intensive type of expanded reproduction. The replacement of obsolete machines and technologies by more progressive ones helps to raise the technical level and quality of the output produced and to increase labor productivity, and it creates the prerequisites for increasing the national economy's effectiveness. When the socialist economy was being built up and strengthened, fixed capital was renewed by accumulating it, since there was, in essence, nothing to replace it with. Then a slight replacement of existing machinery and equipment occurred, which was characteristic prior to the start of the 1970's, when a deficiency of work-force influx was observed.

Gradual transfer to primarily the intensive method of reproduction was planned and consciously implemented during the 9th, 10th and 11th Five-Year Plan periods. However, this transfer still has not been completely supported by renewal of the production potential. The latter is being built up mainly through means of labor that were created on the old technical base and much more rapidly than necessary for the increase in manpower employed. This leads to an imbalance of labor and material resources, underutilized production capacity, and growth of the capital-output ratio.

Moreover, the buildup of production potential by the construction of new enterprises promoted the emergence of a disproportionality of capacity, when, because of a lack of some certain capacity, the utilization of other capacity was hampered. This factor accounted for about 60 percent of the shortfall in output.

[1] Materialy Plenuma Tsentralnogo Komiteta KPSS, 23 Aprelya 1985 g [Papers of the 23 April 1985 Central Committee Plenum]. Moscow, Politizdat, 1985, p 10.

By our calculations, about 500-600 billion rubles will be needed to eliminate these disproportions. This is practically a five-year program of production-type capital construction. Realization of this much work at existing enterprises will require a longer time. The reproduction process must be intensified and its effectiveness raised, with a view to accelerating the loosening up of bottlenecks in the national economy.

The development of production with partial intensification and a capital-intensive form for renewing fixed capital (when the increase in the cost of machinery and equipment overtakes the increase in their productivity) gradually reduced its effectiveness. In combination with the limited nature of labor and material resources, this caused a transfer to comprehensive intensification and the introduction of equipment which reduced the capital-output ratio and enabled productive resources to be saved.

The nature of renewal depends upon the quality and timeliness of arrival of the equipment to replace existing equipment. Under extensive renewal, worn means of labor were replaced by equipment that was newly produced but was based upon the previous technological base or by equipment that was of the same quality but less expensive. However, while the length of series output of the machines does permit such replacement to be made, the cost thereof does not provide for a saving of expenditures.

The intensive form of reproduction is linked with the replacement of aging equipment by basically new equipment, as a result of which intensification is accelerated. Thus the job is to determine the optimal scale of renewal of the means of labor that will satisfy the restrictions as to time and resources.

If fixed capital is renewed in accordance with standard service lives, it means that its retirement from service and replacement occur simultaneously. We keep in mind here that such periods consider the physical wear and the obsolescence of the means of labor.

Capital can be renewed in timely fashion only if the new equipment is sent primarily to existing production facilities, to replace that which is leaving service. Only after these production facilities are completely equipped should the equipment that is left over at that time be sent to new construction and to expansion of the machinery pool. Only under such a distribution priority will renewal be primarily intensive.

In practice, the reverse sequence often takes place. Obsolete machines and equipment that have piled up in existing capital divert labor and material resources in increasingly greater amounts and reduce production effectiveness. According to statistical data, the share of metal-cutting machine tools and forging and pressing equipment older than 20 years increased in 1973-1982. In industry, fixed productive capital that had served more than 20 years rose from 8 to 18 percent, retirements thereof were reduced from 1.7 to 1.2 percent per year, and the capital-output ratio rose 1.2-fold.

A vast production potential which needs improvement, renewal and reorienting in conformance with the solution of urgent problems of intensifying social production has been accumulated in the national economy up to now. A

reduction of the influx of labor resources and rises in the demands for variety and quality of output, for living and working conditions for the populace, and for the technical level and status of the mating of the various production capacities--all these dictate a need not to build up capacity but to improve its balance, to save labor and material resources and to introduce more progressive industrial processes, machines and mechanisms, which will guarantee high quality, longevity and reliability of the articles being manufactured. Forming of the production potential should be accompanied by measures for preserving the environment, improving the infrastructure and bettering the Soviet people's living conditions.

Requirements for the amounts of fixed capital replacement depend upon the level of the production potential that has been created, its condition and the methods for conducting capital operations. On the other hand, replacement is determined by the availability of enough capital investment and the amounts of qualitatively new means of labor that are produced. Usually, renewal is measured by its share of the capital introduced into operation over a definite time period in the total amount introduced by the end of the period. It reflects both extensive and intensive renewal, without distinction, of the means of labor.

The latter includes the portion of the capital introduced which goes to replacement of the means of labor that is retired. The amount of intensive renewal is marked by a coefficient which is the ratio of the share of capital that goes to replacing machinery and equipment being retired to the total volume thereof introduced. The quality of the means of labor which replaces the retired equipment is not considered in this determination.

Fixed capital that is replaced in timely fashion in accordance with standard service lives, its quality and technical and economic levels, and the methods, organization and duration of replacement operations, as well as the availability, in so doing, of labor and material resources--these are the components upon which the effectiveness and amount of renewal of existing production facilities depends. The service time of the fixed capital and its wear, obsoleteness, retirement, introduction and growth rate are interconnected in the reproduction process. The amount of time built up at one instant or another is the outcome of turnover of the capital for operation, the length of operation and the amount of time that it is out of service annually. Consequently, the requirement for capital that is reflected in the amounts thereof introduced and the periods of operation show up objectively as controlling parameters of accumulation. Justification of the length of service of the means of labor is the chief thing in the concept of renewal.

The operating time of the capital reflects the speed of renewal of the productive potential and is one of the most important indicators of the reproduction of the capital. Periodicity of retirement and replacement is characteristic both for individual elements and for the entire total of fixed capital. However, in the latter case, the reproduction period occurs differently.

In the reproduction of capital, correspondence of the length of turnover of the capital's cost to the average service life of the whole aggregate of machines and equipment is important in the reproduction of capital, as

are the level of development of the productive forces and the achievement of technical progress, given maximum possible unity of the change in physical and cost forms of the means of labor. Only by taking this into account can the amortization system function and production facilities be renewed. Achieving equality of the average periods of equipment operation and periods of turnover of the cost of the capital furthers the potential for preservation of the whole cost of the fixed capital that has been advanced and limits the national economy's losses from the physical wear and obsolescence thereof.

Premature retirement of the means of labor increases costs in the form of underamortization. Operating the capital beyond the standard periods reduces productivity and product quality and causes operational and repair expenditures to increase. Methods which permit standard and actual terms of service to be compiled, as well as methods for balancing the amounts of retirements and replacements, both in terms of cost and in physical terms, are necessary for timely renewal of machines and equipment.

Statistical data about the amounts of amortization charges and the presence of fixed capital, the rate of its growth, and the amount of annual retirements enable calculation and comparison of the average actual periods and the standard periods of operation for any reporting year.

The standard period of service is an objectively established length of time of physical wear and the obsolescence of fixed capital which considers these factors optimally. The amortization norm as a measure of annual wear and obsolescence is a reliable tool for planning the reproduction of fixed capital, which guarantees the planned receipt of a substantial portion of the monetary resources for financing capital investment.

According to our computations the share of amortization (for renovation) in gross capital investment now is 40-45 percent. Such a substantial standing source of financing for investment also strengthens planning of the whole reproduction process.

The current amortization system presupposes the execution of standing measures for implementation thereof in accordance with the achievements of technical progress, measures which are considered the path for examining the service life of fixed capital. The desirability of overhaul also is associated with the service life of the means of labor and availability thereof for purposes of progressive replacement of obsolete equipment.

Improvement of the amortization system does not require major expenditure of time. It can be worked out continuously during the preparation and approval of each five-year plan. The criterion for its correspondence to the achievements of technical progress is an approximate equality of the service lives of the capital being retired to the amortization periods. Monitoring these should be a part of the statistical and accounting reporting at enterprises, ministries and agencies. As a result, the potential for preparing changes in amortization norms will emerge and, with approval of the five-year plan, they will be introduced into practice.

In recent years an excess of actual service lives of fixed capital above the standards has been increasing in industry because of decreased retirement

of the means of labor. But this cannot be an adequate basis for reviewing existing amortization norms. It is necessary first of all to analyze the amounts of capital that cease operation as a result of the existing growth rates of capital and the length of the amortization periods. The standard for retiring the means of labor (1.8-1.9 percent per year) does not greatly exceed actual retirements. It could be increased to 3.5-4 percent where the service lives of capital are 15-17 years. Consequently, the existing standards for service life (21-22 years) are too high and the norms for amortization must be increased considerably.

Can amortization periods be brought close to the required level? Here, in our opinion, the specific structure of the capital and the length of the service lives by structural group must be considered, first of all. For example, in the USA's machining industry, the overall standard service life for capital was 15.7 years in 1977, 23.5 years for buildings and structures and 14.1 years for machinery and equipment, while in the USSR in 1983 it was, for the capital under consideration, 20.6 years, 53 years and 14 years, respectively. As is apparent from the data cited, there is a great difference in the service lives for buildings and structures. The share thereof in the capital cost in the USSR is almost twice as much as in the USA. Our production buildings and structures today are more capital intensive and have longer longevity. This depends upon many factors, primarily upon climatic and economic-geography considerations.

The erection of industrial buildings and structures that are lighter in weight is associated, of course, with technical progress in construction and in the building-materials and chemical industries. However, this progress will scarcely allow the share of buildings and structures in fixed production capital to be halved in the foreseeable future. Accelerated growth of industrial production in the eastern and northern parts of the country, naturally, will not help to reduce the share of buildings and structures in capital or to shorten their service lives. In considering the objective conditions for developing our country's production potential, it can be assumed that these periods will be reduced and amortization norms will rise through reduction in duration of operation both of production buildings and structures and of the equipment. As a result, renewal of the active part of fixed capital will be speeded up, but not to a degree that will achieve high levels for all combinations thereof.

In order to increase the pace of renewal of the active portion of fixed capital, then, according to the data of world experience, machinebuilding volume must be increased by about half.

Reduction of the service lives of machinery and equipment and an increase in their share of the production facilities being retired are dictated by the need to renew the means of labor, with a view to raising aggregate productivity (productiveness, usefulness and effectiveness) of all fixed capital. Much depends here upon machinebuilding's potential for producing progressive machinery and also upon the construction field. Periods for creating production capacity often are almost double the standard. If construction time is cut by a half or a third, then (other things being equal), the aggregate productivity of the machines and equipment that are in operation will be built up accordingly. As this task is solved, growth in the capital-output ratio of production will be slowed, with later stabilization and reduction of the level thereof.

Research results indicate that where fixed capital grows at the rate of 2-8 percent, its service life (where retirement is 2-4 percent) reaches 14-25 or more years. Taking into account change in the technological structure of capital expenditures and the specific structure of capital, where the share of construction and installing work in total capital investment is reduced from 42 to 32 percent and the share of machinery and equipment rises accordingly, service lives will be 7.5-8 years. It follows from this that the upper limit of retirement in the amount of 4 percent when the capital growth rate is, for example, 6 percent, will be reached when the service lives of machines and equipment are 8-9 years versus the actual 15-18 years. Their retirement and the corresponding renewal will be realized where there is a two-fold speedup in the rate of growth of machinebuilding production over the existing level. In our opinion, where capital growth rates are 4-6 percent, the retirement of capital in amounts of 3.5-4 percent is the maximum possible.

In order to replace this retired equipment at a capital growth rate of 4 percent, the amortization norms for renovation should be increased, because the existing norms cannot provide for the replacement of capital that goes out of operation where the existing buildup of capital funds does not exceed 2 percent of its value at the start of the year. Of course, the amortization charged annually greatly exceeds the cost of the means of labor being retired and the expenditures for replacing them. However, there can be equality of retirements and of amortizations for renovation only when reproduction grows, and during expanded reproduction and the maintenance of a regular movement of capital a definite relationship develops between retirement and amortization, which is a function of the service lives and rates of growth of the capital. Thus, where growth rates are 4 percent and retirements 3.5-4 percent, to which service lives of 17-18 years for all capital and 11-12 years for the active portion correspond, the share of retirement and amortization for renovation should be, according to our calculations, no more than 70-72 percent. With an acceleration in the rate of increase of capital, this share is reduced; already at the current rates of 7-8 percent, and given the same service lives, it is reduced to 48-50 percent.

Based upon the data cited, it can be concluded that, in order to provide the capital investment resources necessary for the proposed increase of up to 3.5-4 percent in the retirement of fixed capital, the existing norms for amortization for renovation should, given ordinary refinement, be raised on the average by 20-22 percent, the overall rise thereof being achieved mainly through a substantial reduction of the service lives of machinery and equipment and a limitation of expenditures on overhaul. According to preliminary calculations, such expenditures could be reduced by 15-18 percent. The norms for renovation and expenditures for overhaul can be refined by reevaluating the fixed capital and reviewing the amounts of the amortization charges.

Change in the reproduction process mode in order to speed up fixed capital renewal will be realistic only in close correlation with material support. Retirements of capital in the amount of 3.5-4 percent where the growth rate is 4 percent is possible where the buildup of production of the means of labor is accelerated 1.4-fold to 1.5-fold.

Capital investment resources are a restraining factor in the required increase in retirement of fixed capital. Almost three times as much will be

required for replacing retired capital as at present. Therefore, a radical reorienting of capital investment to existing production facilities is necessary. Given the substantial backlog of accomplished construction work at new construction sites, at least 5-7 years will be needed for such a reorientation by restricting newly started new construction.

The reproduction structure of existing production facilities is a means for reorienting capital investment to them. It also can be a good tool for planning retirements and for replacing fixed capital at enterprises, because it enables planning and economic organs to plan reproduction through new construction and existing production facilities as a whole. It enables the organizational structure for capital investment and the economic mechanisms for more rapid and effective realization of capital investment to be improved.

In 1980-1983 capital investment (not counting expenditures for equipment not included in the construction projects' budget estimate and for developmental and deep exploratory drilling for oil, gas and thermal water) was distributed as follows: for new construction 35.8-36.3 percent of the total volume thereof, for expansion and upkeep 31.8-28.9 percent, and for rebuilding and reequipping 32.4-34.8 percent. If the standard procedures for reproducing capital and renewing it are observed and capital is renewed in accordance with standard service lives, the reproduction structure of capital investment, as calculations indicate, will be greatly different from what has been cited. Thus, no more than 20 percent of the annual total of capital investment would be allocated for new construction, up to 23 percent for expansion and upkeep, and up to 57 percent for rebuilding and reequipping. The standard structure determines the saturation limits of capital investment for a production facility, based upon the standard (which needs refining) service lives of fixed capital, conditional upon the periods of operation and the dates of retirement and renewal of the production apparatus. In order to allow retirement of capital to equal 3.5-4 percent, the reproduction structure should be reoriented still more in the direction of an increase in expenditures for existing production. Such a structure can be taken as transitional.

For the effective rebuilding of existing enterprises, it is desirable to conduct a full set of predesign and design operations for each form of reproduction. These operations should be specially intensified or even organized anew for rebuilding and reequipping. These forms today require the same attention of designers and surveyors as expansion and new construction do. It is at times more difficult to introduce new equipment and new industrial processes into an existing production facility than to draw up a design for and erect a new enterprise. It also is not easy to arrange for an effective tie of a rebuilt production facility with its cooperating and dependent enterprises without a predesign stage.

Predesign documentation, designs for reequipping and rebuilding and designs for organizing operations should reflect and consider, aside from the technical solutions, the ties within the production facility and sector and intersector ties in the matters of providing the enterprises being equipped with labor and material resources and of marketing the finished output. Obviously, the time has come to grant design organizations and enterprises the right to conclude contracts for carrying out design and surveying

operations without restriction on the budget-estimated cost for rebuilding and reequipping, that is, without the observance of ceilings. In so doing, it is recognized that the established ceilings will be observed at the appropriate management levels when questions of including construction projects in the state plan and of financing the work determined by the designs are resolved.

In order to carry out the design and surveying work for the reequipping and rebuilding of existing enterprises, contracting design organizations should have specialized subunits and should bear responsibility for establishing and changing the design capacity on the basis of which the production facility is planned. In order to avoid subjectivism and bureaucratic maneuvering, "self-determination" of production capacity by enterprises is impermissible in economic practice and planning. In planning and executing reequipping and rebuilding, a unified procedure apparently should be established that calls for the presence of fully approved design documentation for operations that cost, let us say, 100,000 rubles or more (regardless of the sources of financing). The capacity established in the design thus is the most important feature of an enterprise on the basis of which production volume is planned.

The effectiveness of reequipping and rebuilding depends both upon the level at which it is conducted and upon the replacement of obsolete technologies, machines and equipment by new ones. In order to improve operations for rebuilding and reequipping, their predesign validation and design work should be promoted and the amounts of the latter planned by ministry and agency. As a result, it will be possible (based upon the design and budget-estimating documentation) to plan retirements of fixed capital and the replacement thereof. In planning the distribution of equipment, priority in supporting the designs of existing enterprises will be observed.

In order to raise the technical level of enterprises being reequipped and rebuilt and also to accelerate their renewal, it is desirable to create flexible production systems, which facilitate the replacement and modernization of the industrial elements and of individual machines. Also necessary are standard developments for the design and creation of modules that are ready for construction and installing operations, the execution of which would be incorporated in the annual amounts of operations and would not cause an increase in the consumption of expensive materials. Finally, the main things are the availability of new equipment and progressive technology and an acceleration of their introduction. With a view to saving social labor, the rates of equipment renewal and technical progress should correspond, that is, the service lives of the machines should be brought close to the periodicity of the appearance of basically new equipment. Realization of such a requirement also is linked with the necessity for accelerating the buildup of machinebuilding-output volume and reduction in the time spent creating production capacity.

11409
CSO: 1823/243

INDUSTRY PLANNING AND ECONOMICS

UDC: 658.53:658.527.011.56

STANDARDIZATION OF LABOR OF WORKERS IN FLEXIBLE PRODUCTION SYSTEM

Moscow MASHINOSTROITEL' in Russian No 4, Apr 85 pp 34-36

SABLUKOV, V.A., Chief, Office of Standardization, 'Krasnyy Proletariy' Machine Tool Building Plant imeni A.I. Yefremov; CHARUKHIN, Yu.V., Engineer.

[Abstract] The flexible production system refers to a set of program controlled devices, industrial robots with expanded functions, automated storage areas, flexible part transportation devices and highly reliable automated control systems based on microelectronics. This article describes functions which may be performed by workers to fulfill a production assignment in a flexible production system with highly automated operation. Workers must interact with computers, receiving production assignments from them and adjusting control computers and equipment to perform the assigned job. Equations are presented for standardization of the time required to perform various aspects of this work. Calculation of the consumption of labor and determination of labor measures must be performed on the basis of analysis of the types of labor required for production of a batch of product.
[157-6508]

CSO: 1823/157

UNDER NEW CONDITIONS

Alma-Ata NARODNOYE KHOZYAYSTVO KAZAKHSTANA in Russian No 1, Jan 85, pp 34-37

RUMYANTSEV, L.

[Abstract] In the past year the enterprises of five ministries were given expanded rights in terms of planning and economic activity plus increased responsibility for the results of their work. This year the enterprises of 21 more union and republic ministries were given these new rights and responsibilities. This article discusses the effect of the new working conditions on working teams at the Alma-Ata Order of Red Banner of Labor, Heavy Machine Building Plant. The Plant director has approached the new conditions carefully, saying 'Measure seven times, cut once.' In spite of his caution, a great deal has been done; brochures and memoranda have been circulated, methodological materials have been studied, meetings have been held at the ministry, quotas have been simplified. Greater attention is given to introduction of new equipment. Some inertia of the old style of leadership is being noted, however. The number of workers released for cause has increased, as have nonproductive working time and sick leave. [155-6508]

CSO: 1823/154

METAL-CUTTING AND METAL-FORMING MACHINE TOOLS

UDC /621.865.8+621.9.06.002/ :629.118.6

MACHINE TOOLS MADE IN-HOUSE TO MODERNIZE OWN PRODUCTION

Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 4, Apr 85 pp 3-5

/Article by V. V. Ovcharuk of the Lvov Motor Plant: "In-House Robot and Machine Tool Building (The Experience of the Lvov Motor Plant)"/

/Text/ The operational introduction of motor bike production models, developed with the wishes of the market in mind, is inconceivable without the fast and continuous renovation of production based on the introduction of modern achievements of science and technology, during which these achievements often must be used under conditions which permit the maximum expression of design and technological solutions made when developing prototypes.

The automation of production, particularly the development and introduction of multi-operational machine tools with programmed control and robot equipment complexes of its own manufacture, is one of those directions in the activities of the Lvov Motor Plant.

It should be noted that the plant began its intensive involvement with its own machine tool building in 1976 when 40,000 rubles worth of equipment was manufactured. Those machine tools performed 2-3 technological operations. However, they required constant attention: a worker set up the part in the machining area, the machine tool performed the prescribed technological operations, and the cycle was repeated. An economic savings was achieved because of a reduction in the equipment used on individual technological operations and an increase in the quality of the parts.

Later those machine tools were equipped at the plant with special bin-loading devices which eliminated the repetitive manual operation of setting up the part in the machining area. As a result, the worker-operator's task was reduced to loading the parts in the bin. All of the other things--feeding the part from the bin to the machining area, its machining, removing and loading it in a package--were done by automatic machine tools.

In order to equip the machine tools with bin-loading devices, they had to abandon the electrical equipment relay circuits and switch to transistorized integrated circuits. Electronics and machine tool building design groups, which not only developed new circuits but also introduced them into their own newly-created machine tool building shop, which was created in 1978, accomplished this task.

Metal-cutting, forging and pressing, bending, and straightening equipment is now being designed and introduced at the plant. Their basic units--hydraulic drive, hydrodistribution device (hydraulic panel), bin-loading device, as well as actuating mechanisms and an electronic control system--are standardized, compact, and easy to operate. Automatic and semiautomatic machine tools are also being developed and introduced to weld parts for children's bicycles and mopeds: the plant has manufactured 94 of them in eight years.

Based on equipment produced by the plant, multiple-machine servicing sectors are being set up where one worker operates 4-6 multi-operational (from 2 to 4 operations) machine tools with programmed control. Two of these sectors are now in operation: the machine and welding shop which produces parts and assemblies for children's bicycles and the frame and press shop which manufactures parts and units for assembling mopeds. The economic expediency of such centers is evident. For example, the machine and welding shop alone, where 17 multi-operational machine tools with programmed control were installed, succeeded in freeing 12 workers.

With the increased demand for motor bike products in mind, the plant has developed a program for the speedy introduction of new articles, an important place in which is assigned to an increase in the effectiveness of work on their own machine building including, because of automation, machine tools of their own manufacture and an expansion of the products list of parts manufactured on them. (The plant already has in production at the present time the first models of quickly-readjusted machine tools supplied with automatic blank-loading systems for bending the handle-bars of children's bicycles of various modifications and the assembly frame crank of a child's bicycle). A large role at this time is assigned to measures on introducing brigade work methods and wages, increasing the machine shift coefficient, a material and moral incentive for quality work, as well as training attendant personnel with the skill to correctly operate machine tools and automatic equipment, etc. All of this harmonizes with the systematic growth in the enterprise's capacities and the re-tooling of operational processes and shops. For example, during 1983-1984 alone, an automated production line for painting bicycles, three automatic electroplating lines, and a conveyor to transport parts through the entire technological cycle became operational at the plant, a shop for manufacturing parts and assemblies was established, and the assembly shop was modernized. Among the things put into production were three aggregate machine tools and 14 machine tools of their own manufacture.

The automation of processes based on industrial robots and manipulators of their own manufacture occupies a very large place at the plant. Suffice it to say that the first design of an industrial manipulator was developed and introduced at the plant as long ago as 1978. It was a unit with a loading and storage device and a mechanism for feeding the moped sprocket into the forging area. Such devices were later introduced at the plant's heat section to feed the same sprocket into the firing area. They are now still in operation and have fully eliminated the probability of a person's hand being caught in the part-machining area. It must be said that the production workers very quickly appreciated the value of these devices and, therefore, they mastered them quickly and are now maintaining them in constant working order.

First-generation industrial manipulators also found a place in the forging sector of the frame and press shop where the work is especially monotonous and therefore there is the danger of injury. Thanks to six of these manipulators at the new part-stamping sector, they have succeeded in significantly decreasing the number of workers engaged in this work. At the same time, of course, they had to revise the design of some parts, making them suitable for robotization, and change the design of some punches, supplying them with special dies suited for dropping a part through pneumatic blowing.

The search for resources to decrease work places led to setting up special storage areas with the vibration-directing feeding of blanks. Such a feeder permits the elimination of the operation of directing blanks and installing them in packs, and increasing the operation area from 6 robots to 10. It directs the blank into the area of the hand claw. The operator's only assigned function is to periodically load 70-100 blanks in the assembly bins, keep track of equipment operation, and do the re-setting.

Second-generation robot-manipulators were developed and introduced at the plant in 1982. They have three degrees of freedom and can operate multi-positional dies. The complete set of each of them has an MP-9S robot (the manufacturer is VAZ/Volga Motor Vehicle Plant/) proper and a feeder with the vibration-directing feed of blanks to the cold-stamping press. One of these systems frees nine workers.

It must be said that these systems already have elements which give them a definite technological flexibility. As an example one can cite the robots used in machine production which have individual assemblies that are re-set through special clamps, vises, jaws, etc. The first of these robots has been installed in the automatic machinery shop which permits the creation of yet another robot equipment sector which is operated by worker-operators and frees pieceworkers.

A robot equipment complex which includes two industrial robots and a three-position die on one press for manufacturing lugs is a development of the plant in the area of robot building which was introduced in 1984. The introduction of this complex permits the solution of a whole series of important production and social problems. It decreases the amount of equipment required (three presses and, accordingly, three dies); allows a reduction in the number of work places and, consequently, workers involved in the production process; increases the skill of the workers; leads to a growth in the equipment workload ratio (and this problem, as is well known, is one of the most urgent lately). The plan is to introduce three more of these complexes in the future.

A program to also robotize the painting process was developed and is being carried out. In particular, two RB-211 robots have already been installed on the painting line. When moving the suspension arms with parts into the robot's area of activity, the latter identifies (by a signal flag identifier installed on the suspension arm) the configuration of the part and moves the paint sprayer in precise conformity with this configuration.

A robot building bureau, which is in the plant's division of production automation and mechanization, handles the planning, development, manufacture and introduction of robot technology at the plant. Strategic problems in developing robot building are examined at the enterprise's technical council; the plant's chief engineer performs the coordination and general management of the entire operation.

If you talk about the economic effectiveness of introducing their own machine tool and robot building, then it should be stressed that robots and modern machine tools of their own manufacture allow not only a decrease in the number of work places but also an improvement in the social and psychological climate in the collective because of the creation of optimum working conditions; the elimination of dangerous injury (stamping) and unhealthy (painting) work. Moreover, the technical literacy level of the attending personnel is increased, the name of the workers' professions themselves and, which is of no small importance, the attitude of the managers toward the introduction and condition of new equipment are changing. For example, the downtime of robots and machine tools with programmed control sharply affects immediately the fulfillment of the production plan which forces the subunit managers to continuously monitor the working order of the equipment in the automated sectors and create special maintenance groups. Another important thing is that machine tools with programmed control and robot equipment permit an increase in production quality: they machine parts in strict accordance with design dimensions and, when deviating from the design, they do not simply remove the blank for machining but their electronic control system immediately switches off the equipment.

The development of their own robot and machine tool building, planned in connection with the introduction of new part models developed with the sales market in mind, permits the plant to fulfill the planned technical and economic indicators in a stable manner. Thus, in 1984 the Lvov Motor Plant fully replenished the products list of its output. And nevertheless, 30.4 percent of it was immediately awarded the State Emblem of Quality and 17.4 percent was produced with the "N" index. The annual shipment plan was fulfilled by 100 percent, labor productivity growth amounted to 103.9 percent, expenditures per ruble of commodity production were decreased by 0.74 percent, losses from intraplant defective output turned out to be considerably less than before. These facts speak for themselves.

8524
CSO: 1823/223

METAL-CUTTING AND METAL-FORMING MACHINE TOOLS

UDC: 658.310.33:[658.3-057.21:621.941.28.529

MULTI-MACHINE SERVICING OF PROGRAM CONTROLLED TURRET LATHES

Moscow MASHINOSTROITEL' in Russian No 1, Jan 85 pp 36-37

MAKAROVA, I.V., Engineer

[Abstract] In order to determine the reasons for significant nonproductive expenditures of working time by the operators of program-controlled turret lathes, analysis of their activity during a working shift was performed. Studies included full photographic chronometric studies at two plants, selective time and motion studies at a third. Analysis showed that the significant variation in time expended in installation, adjustment and removal of large parts on the machines was related to the need to adjust the position of the part on the surface plate, a process which is particularly lengthy if the relative position of the part surface worked in the previous and present operations must be adjusted. The greatest amount of secondary time is that spent in adjustment of assembled sections and installation of parts with worked surfaces of identical size. Time spent in installation and adjustment of parts increases toward the end of the shift. The major factor requiring operators attention is the accumulation of chips on the surfaces being worked. Automation of chip removal would reduce the number of times workers must approach the machines. Servicing of multiple machines requires higher level of organization and servicing of working locations. Workers must frequently stop working before the end of the shift, in order to pass the machine along to the next shift without a part in process of being worked on the machine at the transition. Organization of work so that the machine need not be clear at shift change would increase the productivity of labor.
[142-6508]

CSO: 1823/157

METAL-CUTTING AND METAL-FORMING MACHINE TOOLS

BRIEFS

KRASNODAR COMPUTERIZES MACHINE TOOLS--Krasnodar (TASS)--Since the beginning of this year, the Krasnodar Machine Building Plant imeni Sedin, which manufactures about 70 different versions of machine tools, has begun to operate in conditions of an economic experiment. Microprocessor-equipped machine tools have been installed in the plant's shops. Unlike their predecessors--machine tools with NC--they are simpler to service and need no special equipment to set up their programs. In the photograph [photograph not shown], we see a new microprocessor-equipped machine tool. [Text] [Moscow EKONOMICHESKAYA GAZETA in Russian No 8, Feb 85 p 7] 12659

USSR IMPORTING AUSTRIAN LATHES--Vienna--The Austrian machine building firm Heid is well-known in a number of countries. It has been shipping its products into the Soviet Union for over 60 years as well. But if the firm previously specialized in agricultural equipment, today Heid manufactures up-to-date complex machine tools with NC. In the Lower Austrian city of Stockerau, home of the Heid plants, there is a festive mood: a delegation from the firm has just returned from the Soviet Union bringing with them a contract signed in Moscow for deliveries of a number of machines to the USSR prior to the end of 1986. In addition, they have concluded an agreement whereby the Heid Firm will manufacture a number of lathes with NC for the Soviet Union. This fact is proof that growth in the economic relations between the Soviet Union and Austria is on the upswing. [By IZVESTIYA correspondent] [Text] [Moscow IZVESTIYA in Russian 12 Jul 85 p 1] 12659

TASHKENT'S MULTIPURPOSE MACHINE TOOL--A special machine tool has been developed in the Tekhnolog NPO [Scientific Production Association] for milling surfaces and slots in large-sized parts. Heretofore, these operations called for two machine tools--a radial drilling machine tool and a horizontal milling machine tool. Large production areas were needed, as well as a large number of personnel. In this new machine tool, the problems of tool-cooling and metal shavings removal have found an integrated solution. The annual economic effect derived from use of the new machine tool comes to about R12,000. It has been introduced at the Tashkent Aggregating Plant. [By S. Polynova (from UzNIIKTI data)] [Tashkent PRAVDA VOSTOKA in Russian 21 Nov 84 p 3] 12659

KHARKOV TRACTOR PLANT AUTOMATED--Kharkov--The Kharkov Tractor Plant collective is increasing production of its 150-horsepower Plowman caterpillar tractors which have replaced machines, now taken out of production, with half their power. In connection with this, there has been a radical renovation in many of the plant's shops and sections. In place of the all-purpose equipment which has now been dismantled, they have installed robot-equipped complexes, automatic production lines and machine tools with NC. The main conveyor has been converted. The production of powerful caterpillar-drive equipment, which is badly needed particularly in the cultivation of the Ukraine's fertile chernozems, is now being increased 2.5-fold in comparison with last year. [By A. Vyatkin, SOTSIALISTICHESKAYA INDUSTRIYA correspondent] [Text] [Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 18 Jan 85 p 2] 12659

BERDICHEV PLANT'S LABOR-SAVING MACHINES--Zhitomir--The collective of the Komsomolets Plant in Berdichev has acquired five new machine tool models since the begining of the five-year plan period. It is calculated that at enterprises where these machine tools are in operation, it will now be possible to release about 10,000 workers. The enterprises are presently witnessing the initiation of production of robot-equipped turret lathe machine tool complexes, where NC units are supplemented with manipulators for feeding blanks and removing finished parts. They are bringing about a considerable increase in the equipment's productivity and are saving labor in the machine building enterprises' shops. [By Zh. Tkachenko, SOTSIALISTICHESKAYA INDUSTRIYA correspondent] [Text] [Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 21 Feb 85 p 2] 12659

KIEV ASSOCIATION'S MULTIPURPOSE LATHE--Kiev (TASS)--A combination lathe and machining center with NC which has been recommended for series production is the progenitor of a new generation of machine tool units in production at the Kiev Machine Tool Association. With its 20 tools, it can complete the entire cycle of parts machining with no participation by humans, and in so doing takes the place of 3-4 all-purpose machine tools. The unit was developed as part of an ahead-of-schedule program to increase the technical level of output which program is being carried out in the association. The basic "trade" of the enterprise is the manufacture of automatic machine tools and production lines. Their high degree of productivity, precision and reliability have made them irreplaceable anywhere there is mass and large-series producton of parts. But allied sectors also have an even greater need for other equipment--multipurpose equipment which can be readjusted easily and quickly, which is important when manufacturing medium-sized and small series of parts. These are precisely the requirements which the combination lathe-machining center, which has gone from the idea stage to the experimental model in less than three years. The plant has also succeeded in greatly expanding the production potentialities of their series-produced automatic lathes. Having preserved their previous virtues, they have mastered "allied specialties", and are now capable of milling and drilling. This means that each of them replaces several regular units which had to have maintenance personnel. The plant is developing a sequential range of machine tools. Their "assignment for tomorrow" has turned out to be complicated, but the experience accumulated during the development of the machining center is helping the designers. They plan on turning over the final blueprints to the producers in August. [Text] [Moscow SOTSIALISTICHESKAYA INDUSTRIYA in Russian 12 Feb 85 p 1] 12659

CSO: 1823/204

JPRS-UMM-85-013
16 October 1985

AUTOMATED LINES AND AGGREGATED MACHINING SYSTEMS

UDC 621.001.7

FUTURE FACTORIES, FMS IN SOVIET INDUSTRY VIEWED

Moscow MASHINOSTROITEL in Russian No 6, Jun 85 pp 30-33

[Article by Dr of Technical Sciences, Professor Ye. N. Maslov: "The Future Factory Is Being Born Today" under the heading: "Mechanization and Automation of Production". Passages in capital letters were in boldface in source]

[Text] The machine building of our country, in the volume and variety of products produced, occupies one of the leading places in the world and is a continuously and rapidly developing sector of industry providing for much of the progress of the whole national economy of the country.

What will the machine building factory of tomorrow be like? The complexity of the answer to this question proceeds from the multifacetedness of machine-building, from the huge variety of machines being manufactured (the variety of purpose, sizes, complexity, accuracy, and so on) at plants with different types of production (single-unit, serial, or mass production) with various equipment and technologies, from the level of mechanization and automation of the manufacturing processes, and from the organization and management of production and so on. Nevertheless, this question also can be answered simply; namely, that the machine building factory of the near future will have such characteristic features as profound objective and technological specialization, high-productivity equipment and advanced technology, an effective organization and progressive methods for managing it.

The widespread use of the great achievements of fundamental research in the fields of physics, chemistry, electronics, mechanics, and other scientific areas will bring about new vigorous progress in the development of machine building. For example, the rapid development of the physics of high pressures already has permitted the development of a large group of new materials with special characteristics (superhardness, superstrength, temperature resistance, high magnetic properties, and others). A group of superhard materials (based on synthetic diamonds, cubic nitrides of boron and their composites) has become especially important in the manufacture of various cutting tools having high hardness and assuring the effective operation of flexible automated systems. The development of powder metallurgy is the basis for the manufacture of parts with little or no scrap. The application of powerful modern laser equipment has increased the efficiency of a whole series of manufacturing operations, for instance, the machining of articles made of superhard materials, the heat treatment of metals, and so on.

Basic research in various fields of chemistry has created the conditions for the use at plants of new electrochemical processes, high chemical energy, corrosion-resistant coatings, effective lubricating and cooling substances for machining, and so on.

The intense development of electronics has permitted the development and introduction of compact mini-computers for integrated systems with elevated fast action which, combined with mathematic methods have opened up unprecedented prospects for the solution of practically any scientific and technical problems including those in the field of the design of new machines and the development of progressive production processes. With the widespread introduction of the results of theoretical and experimental research in the field of the mechanics of continuous media (regarding the elasticity and creep of metals) much progress already has been made in the processing of metals with pressure (extrusion, stamping, and so on). Improvements in the methods of manufacturing blanks by precision stamping, by rolling, casting, and welding, and the introduction of special rolled shapes have increased the coefficient of the utilization of metals in mass production to 85-90 percent.

Up to the present, scientific and technical progress has facilitated a substantial renewal of the machine building of our country. Its technology and the equipment for it have been intensively improved primarily in the mechanization and automation of manufacturing processes which, in turn, determine the level of productivity of all means of production and the implements of labor. Such improvement grows sharply in a transition from single-unit to serial or mass production.

A large scientific and technical program is being realized in our country for further qualitative improvement in machine building by way of developing high-productivity flexible manufacturing systems (FMS) permitting a transition in a relatively short time and with small cost to the production of articles of a different kind, or of improved new design. Flexible manufacturing, which is most productive in serial production, can also be effective in single-unit and mass production. In single-unit production, flexible manufacturing systems can be effective if a group technology for processing is used in the fullest possible measure. In mass production, with the introduction of flexible manufacturing systems, the transition to manufacturing a new improved machine will not be restrained by so-called "rigid" lines; that is, by the nonversatile (synchronous) system of the automatic production lines and manufacturing bays used in mass production. Because of this, flexible manufacturing systems will occupy a leading position in the machine building industry which will permit rapidly, systematically, and effectively improving the large number of machines being manufactured by mass production which, in the final analysis, will substantially accelerate scientific and technical progress in machine building.

The automatic rotary, and rotary-conveyor production lines which characterize continuous manufacturing processes and make it possible to sharply increase the intensification of industrial production also will receive substantial development, including machine building with the machining of materials by cutting or stamping, the manufacture of parts from plastics and powders, casting, and so on.

The machine tool building industry will make demands not only for unified manufacturing aggregates but mainly for automatic complexes for the production of specific articles. Production equipment with ChPU [Numerically Programmed Controls], industrial robots (self-adjusting and remotely controlled), and controls made of electronic computing equipment, all will be improved on the basis of microcomputers and consequently, a further growth will begin of production lines, bays, shops, and plants (especially those for serial production) having comprehensive automation based on flexible manufacturing systems. Scientific developments will be targeted on the development of a unified modular system for building manufacturing aggregates with numerically programmed controls and PR [Industrial Robots] and having a high level of automation and economic effectiveness.

The type PAS MA-1 flexible automatic production line having interchangeable multispindle units is an example. It is fitted with numerically programmed units and industrial robots and is intended for machining the openings of box-like parts by means of rod-like tools (drills, spot-facers, etc.) under serial production conditions. The production line permits furnishing tools in separate blocks (the total number of tools is 298). A feature of this production line is the possibility of stationary recharge or the transport of the multispindle tool blocks to a power pack during the whole time of machining parts.

As production aggregates which, in the near future, will be widely used, the devices with numerically programmed controls and industrial robots having so-called "artificial intelligence" also should be mentioned. These are devices with an engineering system capable of diagnosing a changing situation and automatically selecting a solution for its own further action in accordance with a given production task. The combined computer processing of optical and tactile information permits solving various practical problems having great importance, for instance, in the automatic assembly of machine elements.

Detailed and objective specialization of enterprises will permit developing mass and large-series production with progressive technology, with the broad use of flexible automatic production lines, modular machine tools, and special equipment, and with comprehensive automation of the manufacturing bays and shops which assures the stable production of a high quality product at low cost.

In single-unit production for the manufacture of experimental and unique equipment, production machines which have broad automation of auxiliary services (loading, unloading, controlling, monitoring, etc.) will find application. In single-unit and small-series production, group machining of parts controlled by a computer is assumed and also the use of unified production equipment for repeated use (USP [Standardized Assembly Fixtures?] and so on). Basically, the general machine building standardization of manufacturing processes will be completed taking into account the specifics of the machine building sectors.

Multispindle, multitool machining of parts with high continuity of the process and using a high-productivity multiblade cutting tool are acquiring widespread application. The tool is fitted with cutting elements made of the latest superhard materials (based on cubic nitride of boron, synthetic diamonds, mineral ceramics, and so on) which enable increasing cutting speeds, productivity, and the quality of machining.

The manufacturing outfits of enterprises will be improved particularly by the replacement at plants of obsolete and worn machinery and production implements by more efficient and productive ones having a high level of mechanization, convenience of operation, and taking into account the possibility of their use in flexible manufacturing systems.

The level of mechanization and automation of intraplant transport will be substantially elevated as also will the storage of parts, attachments, tools, and so on. At all sufficiently large enterprises, addressable storages will be in operation (including also those controlled from a computer) with standardized crane-stackers, and racks, and a standard production container with complete set delivery, and retrieval and distribution of loads under automatic and semiautomatic conditions. Similar comprehensively mechanized storages will become an organizing link in the control of the whole cycle of production from the arrival of material to the assembly of the article of production. A rather widespread use will be made of industrial robots in loading and unloading work in various labor consuming operations.

Methods of finish-machining parts which, in many ways determine the quality, reliability, and durability of machines, will reach a high level of development. The production of machine tools for electrophysical and electrochemical methods of machining will grow substantially. In many cases, to replace the usual methods of machining will come combined processes combining cutting with electrophysical and electrochemical methods of dimensional finishing.

A number of enterprises for mass production already are carrying out modernization for the purpose of developing modern, highly-automated flexible manufacturing (for instance, the Leninskiy Komsomol Motor Vehicle Plant, and the Krasniy Proletariy Machine Tool Building PO [Production Association]).

Below are several examples of modern domestic and foreign flexible automated production which are continuously and intensively being developed in the direction of flexibility, comprehensive mechanization, and high efficiency and therefore are characteristic of machine building plants of the near future.

TYPE ASV-20, ASV-21, ASV-22 and other flexible automated manufacturing bays, developed by the Moscow NPO ENIMS [Scientific Production Association of the Experimental Scientific Research Institute for Metal Cutting Machine Tools] with participation by other scientific research institutes and plants, are mainly for machining bodies of revolution under conditions of small-series or serial production with control from a computer. Blanks for the parts being machined can be forgings, castings, rolled products, and so on. The principal subdivisions of a bay are: production, transport, and control.

The production subdivision of the ASV-20 manufacturing bay consists of ten machine tools with numerically programmed control (eight turning tools and two drilling and milling tools of the type for machining a center), installed in sections 4 and 5 (Figure 1) . It also includes section 6 -- for the adjustment and setting up of tools, section 3 -- the OTK [Department of Technical Monitoring], section 2 -- chip collection, section 1 -- the power supply, and section 9 -- chip removal. The transport subdivision contains the intramachine tool transporter 7 and load lifting manipulator 8 installed in zone 10. The controlling computer subdivision was developed for operational production planning and accounting and is based on M6000 and CM1 computers. The full load operation of the manufacturing bay provides for an increase in the productivity of machining articles by a factor of 1.4 to 1.7 compared with the individual use of machine tools with numerically programmed control.

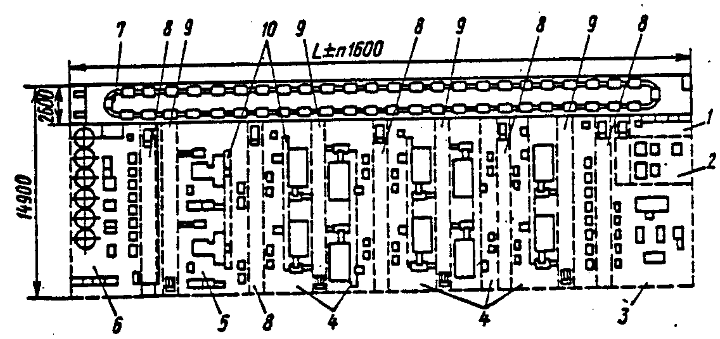


Figure 1.

THE AUTOMATED MANUFACTURING BAY TALKA-500 of the Ivanov Machine Building Production Association imeni 50 Years of the USSR is for machining box-like parts in small-series or series production with control by a computer.

The production subdivision of the manufacturing bay consists of metal cutting machine tools with numerically programmed controls; namely, module IR800, block-center module IR800, globe-center module IR500, and also servicing devices. The transportation subdivision connects the machine tools with the servicing devices and consists of a robot-trolley and its electrical control and railway. The robot-trolley can be replaced by a railless one with inductive control (a robot traller [trailer ?]). An automated storage with a crane and stacker is used for the stowage and distribution of blanks, satellites, parts, tools, and other articles. At loading stations, blanks are placed in a specified position in satellites and sent to machine tools or to storages. There is a two-level control. The upper level is a specialized system based on the SM-2 computer with devices for carrying out stowage, reworking, and the exchange of information with devices of the lower level. In the lower level there are devices for the control of tools with type SNS numerical control and also for control of the transportation subdivision, the automated storage, and the auxiliary devices.

Figure 2 shows the flexible automated production bay, TS-630, (by Fritz Warner of West Berlin) for machining various box-like parts, 1. The production subdivision contains two machine tools , 4, with numerically programmed controls of the machining center type with electrical equipment, 5, a gantry robot, 3, serving the tool storage, 2, and other devices. Each of the machine tools has a magazine for 40 cutting tools. The time for replacing a tool in the machine tool is 4 seconds and the speed of rotation of the spindle is from 20 to 4500 rpm. The blank being machined is moved along three coordinate axes relative to the cutting tool.

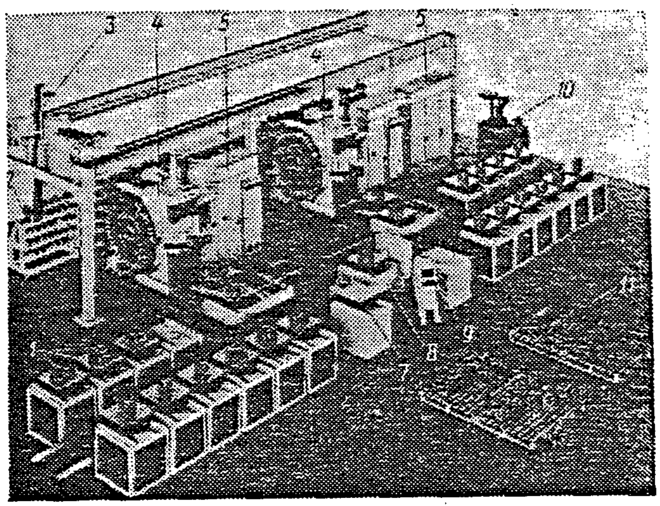
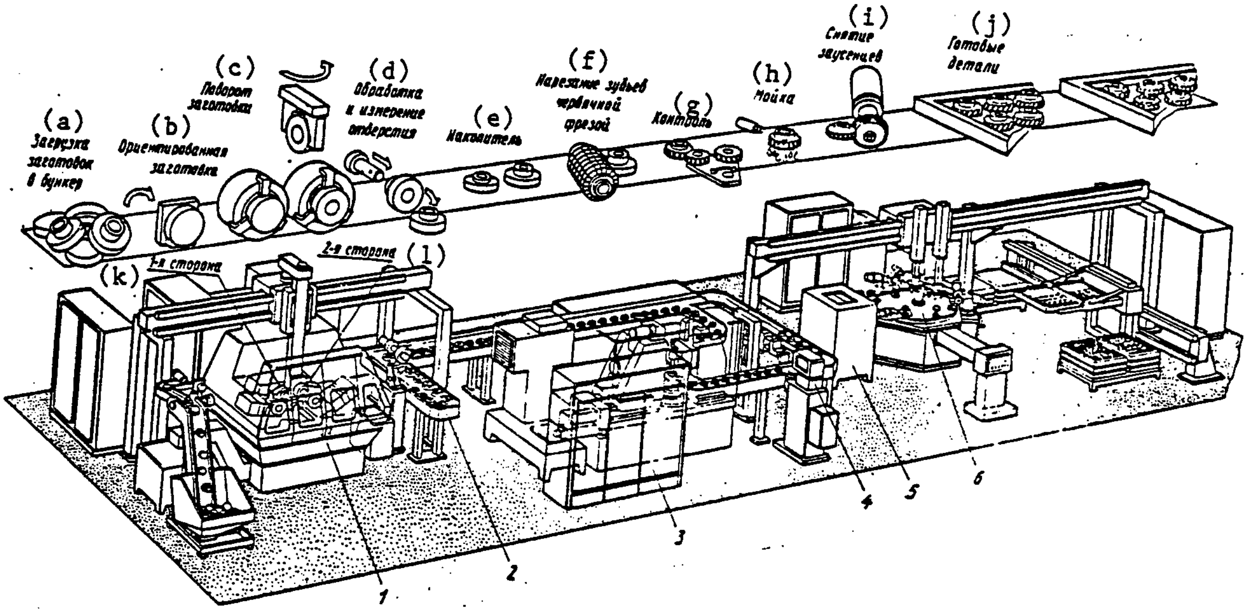


Figure 2.

Before machining, each blank is placed on the satellite, carried to stand 6, and then is automatically installed in machine tool 4. After machining, the blank is removed from the satellite to the loading and unloading station 7. The transportation of blanks and parts with the satellites is done automatically by robot-trolley, 8. The operation of the equipment is monitored by the television, 9, and for the installation and adjustment of a tool, there is instrument 10. For large-series production, the installation can be expanded to four or more machine tools.

A FLEXIBLE AUTOMATED PRODUCTION LINE for the mechanical machining of cylindrical gear wheels (for example, the production line of the G. Pfawter Company of the FRG) has the following kinds of production equipment which operate automatically (see Figure 3): a two-spindle automatic lathe, 1, with the insertion of blanks from a bunker and with the built-in instrument, 2, for measuring a hole; automatic machine, 3,for cutting teeth with a hobbing cutter; an instrument, 4, for monitoring the accuracy of the teeth of hobbed gears; a washing machine, 5; and a multispindle machine tool, 6, for removing burrs on gear teeth. The blanks for the gears are stampings or castings.



Key: (a) loading blanks into bunker, (b) oriented blank, (c) rotate blank, (d) machining and measurement of hole, (e) storage, (f) cutting teeth with hobbing cutter, (g) inspection, (h) washing, (i) burr removal, (j) finished part, (k) first side, (l) second side.

Figure 3.

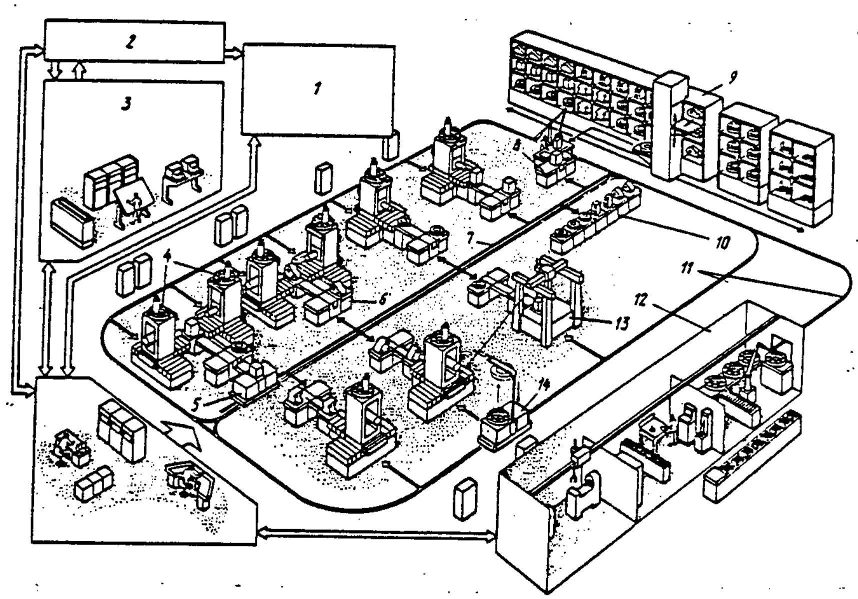


Figure 4.

The flexible manufacturing systems of the near future, in addition to the automated system, 1,(see Figure 4) for control of the manufacturing processes, will have an automated system, 2, for the control of production (ASUP) and a system, 3, for automated planning (SAPR) [System for Automatic Planning of Work]. The ASUP incorporates the scheduling, the calculation of shift assignments, and the monitoring of plan fulfillment. Such manufacturing systems will have: machine tools, 4, of the machining center type with numerically programmed controls, an automated storage, 9; a department, 12, for flexible preparation of production; a storage, 6, with automatic loading; a robot-trolley, 5, for the transport of blanks with satellites; a robot-trolley, 14, for transporting tools; a measuring machine, 13; a loading and unloading station, 8; and an operational storage, 10. The line, 7, indicates the path of movement of robot-trolley 5, and the circumferential line, 11, shows the path for robot-trolley 14. The control of the manufacturing bay is on two levels.

Production discipline is growing in the shops of enterprises which assures the steady receipt of high quality production.

In the metrological provisions for the quality of production, the importance of means for active monitoring will be increased permitting control of the manufacturing processes. So also, the importance will be increased of automated means for evaluating quality, including the reliability (durability) of finished products.

A scientific organization of labor and management makes it possible to structure the manufacturing process more efficiently, it provides for high education of labor and efficient interplay between individual workers, sections, and shops, and it creates the best health and technical conditions at an enterprise. Work will be continued on the introduction of the brigade form of organizing labor. Qualifications will be substantially increased for workers and engineering technicians who carry out the preparation and supervision of the automated manufacturing processes, and the general level of manufacturing will be elevated.

9136
CSO: 1823/236

AUTOMATED LINES AND AGGREGATED MACHINING SYSTEMS

UDC: 658.011.56:621.9

DETERMINATION OF EFFECTIVE PLACEMENT OF EQUIPMENT IN FLEXIBLE AUTOMATED PRODUCTION SYSTEMS

Moscow STANKI I INSTRUMENT in Russian No 4, Apr 85 pp 7-9

STOYANCHENKO, S.S.

[Abstract] A simulation model is used to determine the optimal efficient placement of equipment in a flexible automated production facility consisting of multipurpose machine tools, industrial robots, testing and measurement machinery and other equipment serviced by a nonsynchronized conveyor. The problem of effective placement of equipment along the conveyor is solved to minimize the cost of transportation of products between devices. The flexible automated production facility can simultaneously work on several different types of products, making the problem more complex. The simulation consists of software modules which imitate the process of interaction with the actual equipment. A flowchart of the simulation model is presented. Placement of collection centers for parts along the line is computed in an example problem involving the assembly of instruments from component parts.

Figures 3, references 4 Russian.
[172-6508]

CSO: 1823/155

ROBOTICS

INDUSTRY SPECIALISTS ON ROBOTICS IN FLEXIBLE MANUFACTURING

Highlights of Robotics Conference

Moscow STANDARTY I KACHESTVO in Russian No 5, May 85 p 17

[Comments from the STANDARTY I KACHESTVO editorial board: "Automation of Production and Robotics"]

[Text] As we previously reported (see STANDARTY I KACHESTVO No 1, Jan 85), in Leningrad in December there was a joint meeting of NTS [Scientific-Technical Council] sections from Gosstandart [State Committee for Standards], which we covered in our articles "Industrial Robots and Robot-Equipped Production Complexes" and "Metrological Software" in our general discussion of the question of "Problems in the Development of Robotics Equipment and Its Metrological Software".

V. V. Tkachenko, deputy chairman of the Gosstandart NTS opened the meeting. In his opening address, he said that the 26th CPSU Congress had charged the industry with the tasks of initiating industrial production and introducing basic types of automatic manipulators with programmed control (industrial robots) and equipment complexes outfitted with these manipulators. For the purpose of establishing unified norms and regulations in the field of robotics, Gosstandart, RSFSR Minvuz [Ministry of Higher and Specialized Education] and Minstankoprom [Ministry of the Machine Tool and Tool Building Industry] have developed and are realizing a program of comprehensive standardization of industrial robots which presently encompasses 139 standardizing technical documents. Twenty one ministries and departments are taking part in realizing this program.

Now, in compliance with the decisions of the 26th CPSU Congress, a newer, higher stage in automation--the use of flexible manufacturing systems--has begun. As it proceeds, and as V. V. Tkachenko noted, we are achieving the all-round automation of production, and machine tools with NC are being united in a unified complex along with industrial robots and automated systems for controlling production processes.

The development of flexible manufacturing systems is a complex and all-encompassing scientific and technical problem.

For this problem to come to a successful resolution, the bonds between science and production need to be further strengthened, and we need to unite the forces of our scientific, academic and sectorial institutes, and the specialists from the machine-building ministries and departments.

The new stage in the development of robotics is being opened up by the decree from the USSR Council of Ministers "Accelerating the Efforts to Automate Machine-Building Production Through the Use of Advanced Production Processes and Flexible Readjustable Equipment Complexes". In compliance with this decree, plans call for the manufacture of quite a few more robots during the 12th Five-Year Plan period, which will permit the liberation of hundreds of thousands of the workers who work at unskilled and monotonous jobs.

These key reports were made by the following section chairmen: Ye. I. Yurevich (TsNIIRTK director) [possibly Central Scientific Research Institute for Robotics Design]: "A Program for the Comprehensive Standardization of Industrial Robots for the 11th Five-Year Plan Period and Fundamental Tasks for the 12th Five-Year Plan Period".(Our journal published an article based on the data in this report--see STANDARTY I KACHESTVO No 12, 1984, p 7). Yu. V. Tarbeyev (general director of VNIIM [All-Union Order of Labor Red Banner Scientific-Research Institute of Metrology imeni D. I. Mendeleyev] Scientific Production Association read his report, entitled "Problems of Metrological Software in Robotics and Flexible Manufacturing Systems" (article published below). The report of Ye. T. Udovichenko, general director of the Sistema Scientific Production Association was devoted to the problems of metrological software for robotics systems.

A. L. Vasil'yev, professor of the Leningrad Shipbuilding Institute, devoted his report to the need to use the modular principle to develop robots.

Articles based on the data presented in certain of the reports, devoted for the most part to the problems of standardizing industrial robots as well as standardizing the procedure for testing them, are published below.

Based on the results of the joint meeting of the NTS sections, an improved resolution was adopted, a presentation of which is published on p 30.

UDC 389.14:007.67:65.011.56

Problems with Dimensional Integrity

Moscow STANDARTY I KACHESTVO in Russian No 5, May 85 pp 18-20

[Article by Yu. V. Tarbeyev, VNIIM imeni D. I. Mendeleyev NPO director: "Problems of Metrological Software in Robotics and Flexible Manufacturing Systems"]

[Text] It is unthinkable that GPS's [flexible manufacturing systems] could function normally on any level without the necessary measuring information being available for controlling output quality during the manufacturing process,

and for simultaneously monitoring the efficiency of the GPS and the surrounding conditions as the output leaves the production process. On the whole, flexible manufacturing requires that hundreds of variables in the physical dimension be measured.

Many manufacturing processes can be carried out only in the presence of the most stringent quantitative control of variables at all stages. Without proper metrological software, the most perfect standards will produce no economic effect, and any determinations of quality lose their real value [1].

Moreover one cannot get past the circumstance that the ever-growing volume of monitoring and measuring operations in manufacturing processes are forcing an extremely serious evaluation of their labor-intensiveness--the economic side of this question is becoming very important. And this is corroborated by statistical data: for example, in the radio electronics industry over 25 percent of labor outlays go for monitoring and measuring operations, and in certain new types of production, the share for these outlays reaches 50 percent and higher.

Thus the role of measurements in flexible automated manufacturing is extremely important, and if no systemic study is provided for the metrological software already being designed, then consequently this will turn out to be a bottleneck in the operation of flexible manufacturing systems of various levels.

At present in this country a system of metrological software has been formulated and is functioning successfully. This system has its basis in the activity of the state and departmental metrological services, and it performs an entire complex of measures which guarantee unity and requisite accuracy of measurement in all sectors of the national economy. The general rules and norms for metrological hardware have been set in the standards of the GSI [State System for the Provision of Unity in Measurement], which is constantly being refined as the sectors of the national economy develop, for the purpose of meeting their requirements.

One of the main problems in metrological software for RT [robotics] is the development and manufacture of standardized PIP's [primary transducers] having the needed metrological and reliability characteristics. There are a number of causes which are preventing both transducers and measuring equipment of high-quality from being provided. One of these causes, in our opinion, is the insufficient level of scientific-procedural guidance and coordination of the research work in this field on the part of the base organizations responsible for consolidating the types of products, all of which leads to the duplication of research efforts in different ministries, the manufacture of new measuring devices in the non-specialized enterprises of the varying ministries etc. All of this has a negative effect on the quality of the measuring equipment. The situation is further aggravated by the fact that, in compliance with the prevailing standards, Gosstandart's institutes of metrology are starting their interrelation with the instrument-making enterprises which make working measurement devices at the stage of state acceptance tests, i.e. when the research work has already been essentially completed.

Another reason for the lack of high-quality transducers and measuring equipment is the fact that a number of enterprises are coming up with individual solutions to the problem of how to use these new developments. As a result there has been an increase in the number of instances where measuring equipment has been manufactured solely to meet the needs of the producing ministry, at a time when this equipment could be used to good effect in many of the country's enterprises.

A no less significant reason, and one which also affects the quantity and quality of the measuring equipment produced is that there is no single ministry responsible for the manufacture of an entire series of groups of products for measuring equipment or for metrological software.

One thing which would improve the quality of the measuring equipment being produced, in our opinion, would be to change the prevailing system of metrological inspection of the work of the instrument-making enterprises, i.e. to change over from passively evaluating already-manufactured instruments to vigorously working to establish standards for their quality, particularly at the earlier stages of development. The work, of several years standing, of our NPO getting several enterprises to adopt technical designs and to work out metrological means has been very useful in solving this problem.

Improvements in metrological software for robotics complexes, and their being equipped with samples of measuring equipment would be helped along by increasing the exactingness required of the enterprises developing this equipment. The participation of Gosstandart in disseminating these demands would help, as well.

During 1982-1984 Gosstandart, along with interested ministries, worked up a series of provisional technical standards documents for industrial robotics products. An analysis of these documents revealed that in a number of the standards, for example, the requirements for setting the values and establishing errors in the measurement of variables were not reflected, nor was there anything reflecting the need to conduct metrological appraisals of the technical specifications. It would be advisable, when examining provisional standards and research work on new standards, to interface them with the State System for the Provision of Unity in Measurement standards.

Problems crop up in the organizational plan when outfitting robotics complexes with measuring equipment, but this does not mean that the developing enterprises do not have their own problems.

The questions of metrological software for tests of robotics complexes and the monitoring of their metrological parameters during their operation have been theoretically poorly worked out. The development of automatic self-checking systems with built-in reference standards, standard samples and corresponding mathematical and programming software seems promising. The development of portable model equipment, which is oriented to specific types of complexes, and which makes it possible to carry out checks during operation, is a possible alternative. The presently existing plan by which SI [measuring equipment] is transported "from RSI [possibly robotics measuring equipment] to the standards", will be changed around to "from the standards to RSI".

All of our previous experience in developing our national economy attests to the need for an outstrippingly-paced development in metrological software for major national economic problems, including those of introducing flexible manufacturing systems and robotics.

The integrated approach to the metrological software needed to develop, manufacture, test and operate RTK's [robotics complexes] infers that an analysis of the state of operations will be conducted. The date derived from the analysis should be made the basis of the corresponding integrated metrological software program in which particular provision needs to be made for: a workup of those problems of metrological maintenance of manufacturing equipment, computers, transport units etc., which problems are new to the metrological services; elaboration and introduction of contact-free procedures for checking automatically operating instruments; the development of a system of standard models and implementation of the necessary changes in the system for transmitting unit dimensions; an investigation and certification of the measurement algorithms for a prescribed series of standard models of projects; the development of a system of NTD's [normative-technical documents] in the field of metrological software for robotics as an integral part of the State System for the Provision of Unity in Measurement during the transition from guaranteeing the unity of measurements to controlling the quality of the measurements; the specialization of enterprises for organizing the manufacture of robotics equipment and its components; and the establishment of territorial Gosstandart agencies etc.

This program will speed up the formation of a concept for metrological software for flexible manufacturing systems.

An analysis of metrological software for flexible manufacturing systems showed that the GSI system for insuring unity in measurements is totally acceptable for flexible manufacturing systems.

However, the specific nature of flexible manufacturing systems (the automation of measurements while in motion, the structural variability, the great number of communications channels, the computer interface capability, the availability of systems for uninterrupted monitoring of accuracy, the built in measuring equipment, which includes OSI [not further expanded], etc., dictates the need for continued growth in the organization of metrological software.

In our country, the data on our metrological software traditionally encompasses two basic types of activity:

the playback of units of physical size and the transmission of their dimensions to all the measuring equipment involved in the manipulations, i.e., the insuring of unity in the measurements;

the carrying out of metrological inspection, i.e. checking to see that all the regulations and requirements which insure the needed accuracy of measurements made in this country are met.

In connection with the introduction of flexible manufacturing methods the above forms of activity need to be improved.

First of all, total accuracy in carrying out the operations used in flexible manufacturing systems cannot be provided through the use of traditional methods of transmitting the dimensions of units with measuring equipment, since such transmission is determined by the operation of all the modules, and not solely the measuring equipment. Consequently, it becomes necessary to combine traditional methods of checking measuring equipment, the uninterrupted monitoring of their accuracy (the purpose of which is to eliminate the negative consequences of breakdowns) and outgoing control over the manufacturing quality of the output (continuous quality control or random sampling).

Full automation of all processes poses the problem of finding the optimum form for their interaction.

Among the entire range of problems for metrological software for flexible manufacturing systems, the SAK [automatic monitoring system] is worthy of particular attention, as it provides the required level of output by monitoring the parameters of the material, blanks, instrumentation, accessories, the manufacturing mode, it measures the variables in the production medium and the products at all manufacturing stages, and monitors the maximum efficiency of the flexible manufacturing system by keeping it in good operating condition via its monitoring and by the diagnoses derived from its actuating elements. It follows from the above that when devising a flexible manufacturing system, there is the problem of the optimal distribution of the step-by-step operation checking of blanks and semi-finished products and monitoring of finished products with the center of gravity at the manufacturing stage. Thus by making use of measurement data it is possible to gradually change over from monitoring quality (grading) of the finished product, to controlling quality as the product is being manufactured [2].

The introduction of flexible manufacturing systems is also widening the scope of metrological inspection, and extending it into the quality of measurements overall.

At the present time, there are two prerequisites to converting from providing unity in measurement to control of the quality of measurements, under which are understood the totality of the properties characterized by compatibility of procedures, equipment and conditions for measurement with the requirements of the manufacturing process. This is what is responsible for the need for a radical restructuring of the system of standardization in the field of metrology.

With this object in view, it is advisable to establish a system of normative-technical documents for the field of metrological software for flexible manufacturing systems, in the framework of which solutions could be found for the scientific and technical problems which require regulation. In due time, a system of normative-technical documents for metrological software for flexible manufacturing systems will have to be made part of the State System for

the Provision of Unity in Measurement. As regards the standards of this system (its legal grounds), they by and large should be oriented to controlling the quality of the measurements. In the existing System for the Provision of Unity in Measurement, there are no requirements concerning instrument-making which, considering the need for metrological software for flexible manufacturing systems, already constitutes a shortcoming.

Where you have a system of automatic control for a flexible manufacturing system you cannot isolate the requirements for the operating measuring equipment now being produced and the OSI [possibly basic measuring equipment] paired with it. The transition from insuring unified measurements to controlling the quality of the measurements is vitally necessary, not only as applied to flexible manufacturing systems, but overall. There have been proposals for a transition to a more improved system of standards in the field of metrology made on a number of occasions in the All-Union Scientific-Research Institute of Metrology imeni D. I. Mendeleyev Scientific Production Association, beginning in 1982.

When a flexible manufacturing system is in operation, a combination of measurements of interconnected dimensions are made (mainly linear and angular dimensions, and movement parameters etc.), i.e. complicated indirect and joint measurements. These measurements are made by measuring modules with automatic data-processing blocks, which dictates the need for the best choice of measurement algorithms. In connection with this, there arises the problem of metrological research and the subsequent certification of the algorithms for the prescribed series of standard models for the subject product (for example, standard forms for workpieces).

The algorithms used for measurment must provide the requisite precision and reliability in the results of the measurements for the prescribed standard models of the subject products. Where the real objects deviate technologically from the standard models, the algorithm must remain suitable for use.

Moreover, the algorithms must be prescribed so as to permit the introduction of corrections when substituting one measuring module for another.

As a result a new trend is arising in applied metrology--the certification of measuring algorithms and data processing. If a study on the theoretical plane has already been made by our association and the Leningrad Polytechnical Institute, then the organizational side of the problem requires its own resolution [3].

Until only quite recently, when productive capacity was being set up for manufacture, the developer himself often thought out the measurement principles and methods. These days, as a result of the extreme complication of both the physical investigations and the measuring equipment required for this purpose, metrologists, who know so much about the techniques of the measurement business and its scientific and engineering aspects, have to take upon themselves the work of searching for new measurement procedures. It should be emphasized that the entire effort to develop metrological software for flexible manufacturing systems should begin with a solution to the work-force problem. The

metrologists of the departmental metrological services need to conduct a metrological apraisal of flexible manufacturing systems, starting from the planning stage, and to submit the measurment algorithms of either the automatic control systems or the overall flexible manufacturing systems to a metrological appraisal or metrological certification. All this requires new and higher-level knowledge and skills, compared to the traditional approach.

In their analysis of the problem of metrological software developments for the "Intensification-90" program, Leningrad scientists came to the conclusion that the problems of metrology are closely intertwined with the problems of stability and reliability across the entire spectrum of hardware components now under development. In connection with this, the Standardization, Metrological Software and Reliability Section of the IPK [possibly Institute for Raising Skill Levels]/Flexible Manufacturing Systems, operating as attached to the Leningrad CPSU obkom's Council on Flexible Manufacturing Systems, thought it necessary to look over the state of affairs of flexible manufacturing systems with regard to its reliability. Initial studies in this direction are showing that the flexible manufacturing systems subdivisions for reliability, which have as yet not been set up at all the enterprises, are playing a significant role, and where they do exist, their rights and status do not always meet the requirements of the Intensification-90 Program.

The scientific portion of the Intensification-90 Program needs to be expanded for the fundamental studies in the field of flexible manufacturing systems' reliability. We consider it necessary to support the initiative of the Leningrad scientists to prepare a plan for an additional section for this program.

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JPRS-UMM-85-013
16 October 1985

UDC 06.065:620.1:007.52:65.011.56

Robotics R&D Community

Moscow STANDARTY I KACHESTVO in Russian No 5, pp 20-24

[Article by S. I. Kolpashnikov, I. B. Chelpanov and T. M. Sholukha, of TsNIIRTK (possibly Central Scientific-Research Institute of Robotics Design]: "The Standardization of Industrial Robot Tests and the Metrological Problems of Organizing and Conducting Them"]

[Text] Tests are an integral part of the process of developing, manufacturing and operating PR [industrial robots] and these tests promote the raising of their technical level, improving their quality, reliability and extending their service life.

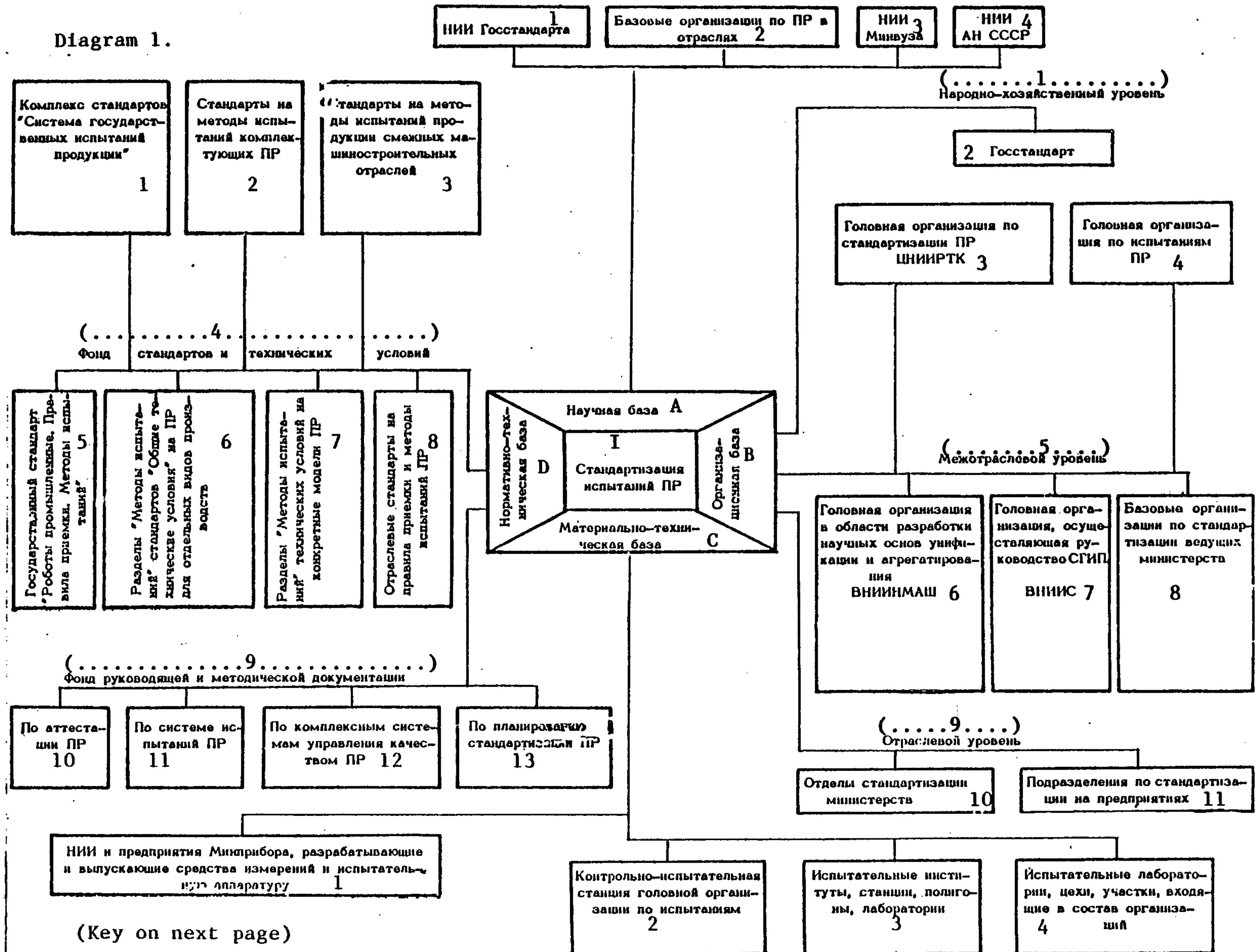
The system of standardization for tests of industrial robots takes in the organizational, normative-technical, material and scientific base (Diagram 1).

The coordination of efforts to standardize and insure technical unity in the area of tests in the national economy's sectors are being handled by leading and base organizations.

The functions of a leading organization for state tests of industrial robots, in compliance with RD 50-172-79, include the carrying out of: acceptance tests prior to delivery of the industrial robots to the industry, check tests of the positioning [ustanovochnaya] series, periodical spot checks, check tests made as part of state inspections of the implementation and observance of the standards and the quality of the industrial robots, tests during certification of high quality categories, tests of those industrial robots earmarked for export, as well as those imported, tests of industrial robots on the demand of enterprises and organizations, as well as in the process of arbitration at the behest of corresponding agencies and consumers; the provision of scientific methodological guidance, and the coordination of efforts for organizing and carrying out tests.

Further improvements in the effectiveness of standardization are being carried out in still greater measure on the level of developing fundamental and applied scientific research, this being conducted by scientific-research institutes of the USSR Academy of Sciences, RSFSR Minvuz [Ministry of Higher and Specialized Education], Gosstandart [State Committee for Standards] and the leading ministries which constitute the scientific base for standardizing industrial robots.

Diagram 1.



(Key on next page)

Key to Diagram 1:

I--Standardization of Tests for Industrial Robots

A--Scientific Base

1--Gosstandart Scientific-Research Institute
2--Base Organizations for Industrial Robots in the Sectors
3--Minvuz Scientific-Research Institute
4--USSR Academy of Sciences Scientific-Research Institute

B--Organizational Base

1--National-Economic Level
2--Gosstandart
3--Leading Organization for Standardizing Industrial Robots: TsNIIRTK
4--Leading Organization for Testing Industrial Robots
5--Intersectorial Level
6--Leading Organization in the Field of Developing the Scientific Bases of Unification and Unitizing: VNIINMASH [All-Union Scientific-Research Institute for Standardization in Machine Building]
7--Leading Organization for Guidance of SGIP [not further expanded]: VNIIS [All-Union Scientific-Research Institute for Standardization]
8--Base Organization for Standardization of Leading Ministries
9--Sectorial Level
10--Departments for the Standardization of Ministries
11--Subdivisions for Standardization in Enterprises

C--Material-Technical Base

1--Minpribor [Ministry of Instrument Making, Automation Equipment, and Control Systems] Scientific-Research Institutes and Enterprises Developing and Producing Measuring Equipment and Testing Equipment
2--Monitoring-Testing Station of Leading Testing Organization
3--Testing Institutes and Stations, Testing Facilities, Laboratories
4--Testing Laboratories, Shops and Sections Which are Parts of Organizations

D--Normative-Technical Base

1--"System of State Products Tests" Complex of Standards
2--Standards for Test Procedures for Complete Industrial Robot Sets
3--Standards for Test Procedures for Products of Associated Machine-Building Sectors
4--Available Standards and Specifications
5--State Standard: "Industrial Robots. Rules for Acceptance. Test Procedures"
6--"Test Procedures" Sections of the Standards "General Specifications" for Industrial Robots Used for Individual Types of Manufacturing
7--"Test Procedures" Sections of Specifications for Specific Industrial Robot Models
8--Sectorial Standards for Rules for Acceptance and Procedures for Testing Industrial Robots
9--Available Reference and Procedural Documents
10--For Certification of Industrial Robots
11--For the System of Testing Industrial Robots
12--For Integrated Systems of Quality Control of Industrial Robots
13--For Setting Up the Standardization of Industrial Robots

The normative-technical base for standardizing tests for industrial robots consists of a collection of state standards, specifications, procedural directives and recommendations. The general requirements regarding the rules for acceptance and methods of testing industrial robots have been set up in GOST 26053-84: "Industrial Robots. Rules for Acceptance. Testing Procedures". In 1984 a number of scientific-research institutes developed a set of procedural recommendations entitled "Tests for Industrial Robots. Orientation of Standardization Operations" as commissioned by Gosstandart for the purpose of insuring a high technical and qualitative level for industrial robots. The condition at present and the prospects for growth of the normative-technical base for standardizing the tests are shown in Diagram 2.

When developing a program for standardizing tests for industrial robots one should separate the following basic directions of the operation:

the development of procedural principles for the experimental determination of the basic groups of indicators for industrial robots;

the establishment of procedures for setting norms for the characteristics to be measured, as well as norms for the requirements for evaluating the accuracy and reproducibility of the results of measurement in the course of testing the industrial robots;

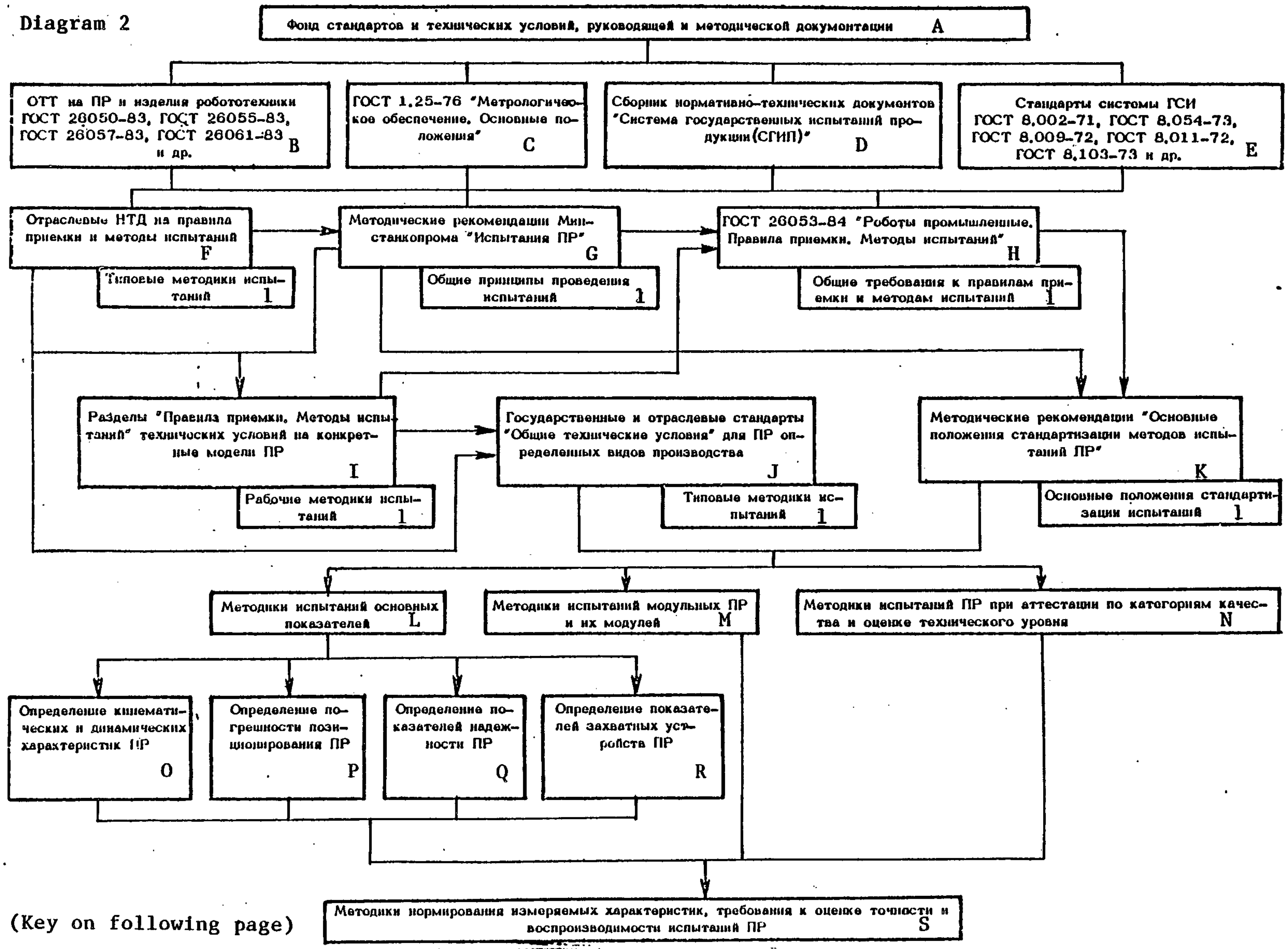
the development of standard and working testing procedures for industrial robots designed for differing purposes (primarily manufacturing robots);

development of general requirements for methods of testing modular industrial robots.

The development of a combination of general technical, organizational and procedural, and metrological NTD's [normative-technical documents] creates conditions in which all the elements of the system for testing industrial robots can develop, conditions which will insure the metrological unity of the tests for the purpose of obtaining correlative and trustworthy results from the measurements taken during these tests, conditions for reducing the volume of repeated tests, and creates conditions for reciprocal acceptance of test results in affiliated manufacturing, during domestic and international barter, and during national and international certification.

The structure of the material-technical base for test standardization anticipates the establishment of an intersectorial monitoring and testing station of the leading testing organization, testing points, testing facilities and laboratories in the main and base organizations of leading ministries, testing laboratories, shops and sections within these organizations and in the enterprises. The foundation of the material-technical base is comprised of the scientific-research institutes and enterprises involved in the development and manufacture of measuring and testing equipment.

Diagram 2



(Key on following page)

Key to Diagram 2:

A--File of Standards, Specifications, Reference and Procedural Documents

B--OTT [not further expanded] for Industrial Robots and Robotics Products: GOST 26050-83, GOST 26055-83, GOST 26057-83, GOST 26061-83 etc.

C--GOST 1.25-76: "Metrological Software. Basic Positions"

D--Collection of Normative-Technical Documents: "The System of State Products Testing (SGIP)

E--Standards of the GSI [State System for the Provision of Unity in Measurement]: GOST 8.002-71, GOST 8.054-73, GOST 8.009-72, GOST 8.011-72, GOST 8.103-73 etc.

F--Sectorial NTD's [normative-technical documents] on Rules for Acceptance and Testing Procedures

F1--Standard Testing Procedures

G--Procedural Recommendations of Minstankoprom [Ministry of the Machine Tool and Tool Building Industry]: "Tests for Industrial Robots"

G1--General Principles for Conducting Tests

H--GOST 26053-84: "Industrial Robots. Rules for Acceptance. Test Methods"

H1--General Requirements for Rules for Acceptance and Test Methods

I--Sections: "Rules for Acceptance. Test Methods" of Specifications for Specific Industrial Robot Models

I1--Working Test Methods

J--State and Sectorial Standards: "General Specifications" for Industrial Robots Used in Specific Types of Manufacture

J1--Standard Test Methods

K--Procedural Recommendations: "Basic Positions Regarding Standardization of Methods for Testing Industrial Robots

K1--Basic Positions Regarding the Standardization of Tests

L--Procedures for Testing Basic Indicators

M--Procedures for Testing Modular Industrial Robots and their Modules

N--Procedures for Testing Industrial Robots During Their Certification to Determine Their Quality Categories and During Evaluation of Their Technical Level

O--Determination of the Kinematic and Dynamic Characteristics of Industrial Robots

P--Determination of Defects in the Positioning of Industrial Robots

Q--Determination of Reliability Indicators for Industrial Robots

R--Determination of Indicators for Gripper Devices in Industrial Robots

S--Procedures for Setting Norms for Measurement Characteristics, for Requirements for Evaluating Accuracy and for the Reproducibility of Tests of Industrial Robots

The greatest problem involved in the formation of of a material-technical base is that of developing primary and secodary instrument transducers and equipment for recording the industrial robot parameters measured in the course of the tests and the provision of the metrological characteristics, first of all the accuracy of the measurements during the manufacturing process, which characteristics have been preserved for use by the manufacturing enterprises. In the absence of a solution to this problem, it is impossible to introduce standardized procedures for testing industrial robotics products and to insure unity in measurement during the tests.

In compliance with GOST 1.25-76, metrological software is seen as the establishment and application of scientific and organizational bases, technical equipment and the rules and norms necessary to achieve unity and the required accuracy of the measurements.

As applied to robotics, the most important problems regarding metrological software on the ministry and enterprise level are the establishment of a list of measureable quantities and their variables, norms for accuracy in measurement and the whys and wherefores of selecting measuring procedures and equipment, the formulation of measurement procedures, the selection of equipment for the processing and recording of the results, and the establishment of rules for presentation of the results of the measurements.

Let us consider the special features of some of these problems.

Among the quantities subject to measurement, we should include linear and angular motions, speeds and accelerations, time intervals, forces and moments, pressures (for robots with pneumatic or hydraulic drive), tension and temperature. It would be a good idea to split up the quantities listed into two groups: basic and additional.

The basic quantities are reflected in the range of technical data, and they directly determine the quality of the functioning of industrial robots (first of all, error). The additional quantities effect the factors, and frequently during the tests, they are merely subject to being monitored (regarding tolerances).

The range of measureable and monitorable quantities and parameters depends on which form of tests they belong to: to investigatory or monitoring tests. For investigatory tests, the range of quantities is considerably wider, and the requirements for their measurement are higher.

The experience accumulated in measuring motions and angles in static conditions in machine building and instrument making can be directly carried over into robotics. When making dynamic measurements the range of frequencies is not very wide, so that even when measuring peak acceleration values the requirements for frequency responses are easily met.

The most demanding measurements for all types of robots are the precise measurements made of a wide range of rotational movements and angles, particularly in dynamic conditions and when carrying out joint movements through several degress of motion, i.e. during spatial motions. Similar difficulties arise during the certification, checking and calibration of associated non-standardized measuring equipment. Metrological software is available almost solely for equipment used to measure linear motion along a single straight line or a turning angle around a single axis.

Robot-equipped production complex for turning bearing races--a collaborative development of USSR and GDR machine tool manufacturers. Labor productivity for small-lot production is increased here 10- to 12-fold.

The principle difficulties are engendered during the process of setting norms for accuracy for the robots.

In the first place, it needs to be borne in mind that a positioning error for Δr , is a vector here, just as the angular error $\Delta\theta$ is considered a vector in orienting a tool in space. The simplest and most universally used method for setting norms for the modules Δr and $\Delta\theta$ of the indicated vectors takes no account of their directions either. However, when using robots for manufacturing sections, tolerances for errors in a variety of directions frequently differ greatly (by several times), and for this reason it seems more correct to set the norms for existing errors in differing directions. This simplifies the procedures for carrying out the appropriate tests as well.

Second, positioning and orientational errors depend to a considerable extent on the position of the tool in the working area; such factors as temperature, supply voltage, the pressure of the working medium, the tuning of the control device elements etc can be essential as well. If the effect of these factors is not critical, then the basic errors can be determined initially (in a given nominal position, and at nominal values for the factors), and the effect of the other factors can be taken into account with the aid of the coefficients

of effect. However, with regard to the position within the working area this usually turns out to be impossible due to the considerable changes in the errors extant within the limits of the working zone.

A very important factor, particularly for industrial robots, is the weight of the object to be manipulated, which causes additional static flexures. Insofar as the relationships of the weight-caused flexures are close to the linear, then in addition to the basic errors it is advisable to normalize the pliability factor (generally the elements of the pliability matrix). Normalization of errors depends on the programming principle. During programmed instruction, where an adjustment is needed for each positioning point, systematic errors are not measured or eliminated during the instruction process; here, associated permanent systematic errors are not normalized. During analytical programming with no adjustment with regard to placement, systematic errors need to be normalized. In this connection, in demanding cases, laws need to be assigned which will change the systematic error in the working zone, for which such geometrical parameters as deviations in the length of the links from the norms, axial angles of transport etc. should be measured and recorded in the manufacturer's certificate during the certification process.

In GOST 25686-83 "Industrial Robots. Terminology and Definitions" we find the sole concept of positioning error free of any sort of specific definition, and that is why the problems listed above have not yet been reflected in the normative-technical literature.

Many of the problems regarding metrological software for industrial robots are closely associated with the tasks the robots are designed to perform. Thus for auxiliary (maintenance) robots with cyclic and positional control, the accuracy of their positioning and orientational functions is determined for prescribed positions, which are conditionally accepted for initial and final positions. In this case, static measurements are essential.

All the remaining measurements (of transport time, linear and angular speeds and linear and angular accelerations) are optional, and for software purposes need not be extremely accurate. For manufacturing robots designed to carry out abrasion work, contour welding and cutting operations, it is important that their operative speeds be maintained, and this is why it is necessary to measure and adjust these speeds (mean and instantaneous values) during their certification and checking.

In the control systems of robots designed to carry out abrasion and assembly operations, measurements of interactive forces and moments are taken with a non-moving installed component, so forces and moments are considered essential parts of these systems.

For manufacturing robots, it is not solely the robot itself which is the subject of measurement, but the production items as well. Conclusions regarding relative quality of the execution of the manufacturing operations should be made according to the results derived from the measurement operation. Here the prob-

lems of metrology are exactly the same as those faced by other production equipment (machine tools, for instance). Unfortunately, the problems of setting norms for accuracy in machine tools have not been worked out to a degree sufficient for the accumulated experience to be carried directly over to them.

It is obvious from the above that it is expedient to classify industrial robots as to type, and to divide the range of normalizing indicators into one group of indicators common to all types and another group of indicators specific for each of the types.

Industrial robots are usually certified en masse. However in some instances it becomes necessary to certify specific devices, elements and systems. Primarily, this concerns modular-type industrial robots, which are constructed on the basis of varying combinations of standardized modules, and concerns robots which can operate with varying control devices and measuring transducers (pickup units) as well.

Metrological software possesses considerable specificity in those instances when its functions are part of a control or measuring system, or themselves act as measuring equipment. Measuring operations which work according to the principle of monitoring and testing machines act as the means for determining variables of form and position for the surfaces of articles (components).

At the present time, similar robots are viewed as non-standardized measuring equipment and have inadequate metrological software. They can be used as part of the monitoring and testing units or as the means by which measuring transducers are transferred (for example when attached to nondestructive monitoring equipment. In these cases, the results derived from the measurements depend on positioning accuracy, and it is for this reason that the robot must be certified together with the measurement transducers.

Metrological software for pick-ups (measuring transducers) is of particular importance. Series-produced motion and turning angle sensors undergo certification, and when operated correctly provide accuracy characteristics in accordance with their prescribed class. At the same time, sensitivity transducers which vary with regard to their actuating principle and are non-standardized and are designed by a number of different organizations as well, are usually not certified. For sensitivity sensors, the first thing which has to be established is their range of basic indicators, which depend upon the quantity to be measured, upon which their activating principle is based.

Certain sensors are per se complex systems. Technical viewing equipment, (particularly television) belongs to this designation. One pressing task is the development of a system of certification for these devices.

Robotics metrology is a very young field, but the situation which has come about requires that metrological software be developed in this field in the shortest possible time. There is also a need for parallel development of normative-technical documents, for them to be promptly corrected, and inspections to be set up to see that the requirements are met. A successful solution

to the problems of robotics, with the subsequent dissemination of the developed approaches to other equipment will insure the required unity of measurement and will insure that the required accuracy will be achieved during the testing of robot-equipped complexes and flexible automated manufacturing operations.

UDC 006.015.2:007.52:65.011.56

Standardization of Robots

Moscow STANDARTY I KACHESTVO in Russian No 5, pp 24-27

[Article by O. B. Korytko, candidate of technical sciences, TsNIIRTK: "Standardization of Industrial Robots and Their Components"]

[Text] GENERAL PROBLEMS IN THE STANDARDIZATION OF INDUSTRIAL ROBOTS

One consequence stemming from the variety of manufacturing problems solved by industrial robots (PR) is the diversity of their designs (there are now some 500 models). This is evidence of the need for robots to be standardized. Two basic directions for efforts in this field can be isolated:

standardization of models, restricted to a single type of robot, within a single sector of the industry;

standardization of all models of robots within a single sector, and then later within several sectors of the industry.

There exist intermediate directions as well.

The first direction has been realized by the majority of foreign firms and domestic enterprises, since this permits the obtaining of an economic effect through short-term implementation. Standardization of existing module-design robots built by the foreign firms (Bosch, Felsomat and Fibro, all of the FRG, Seykosya and Mitsubishi of Japan, Siaki and Nordson of the United States etc.), and by Minstankoprom [Ministry of the Machine Tool and Tool Building Industry] and Minpribor [Ministry of Instrument Making, Automation Equipment, and Control Systems] is being carried out through the development of a variety of modifications of the basic models, and is essentially a particular case of the first direction for standardization.

The second direction can be executed only in those countries with centrally-planned national economies and within the organizational structures of the Council for Mutual Economic Aid.

The determination of a concept for a type and a type size for industrial robots is of paramount importance in developing ideas for standardization. In fact, these concepts were shaped during the all-union and sectorial standardization of the robots built by the machine-building ministries.

Table 1 shows the principle involved in the formation of types and standard sizes for industrial robots from the standpoint of the requirements imposed with regard to the standardization of their designs, as well as through their aggregate features. Robots can be standardized according to the features possessed by the types: the drive, the coordinate system, the structure of the mechanical diagram, the type of control and the manufacturing function, with the primary feature--standardization by type of drive--being the basis for standardization with regard to the remaining features. The relation (the point at which a great number of features intersect) of the manifestations of standardization with regard to the features of the types of robots can be thought of as the range wherein the designs are standardized by coordinate systems and the structure of the mechanical diagram, within which we find the range of standardization by drive type. The range of standardizations according to type of control and manufacturing function intersects with the above-named ranges.

Table 1: The Principle by which Types and Type Sizes for Robots are Set Up

(I) Признаки типа робота			
(a) Тип привода	(b) Тип системы координат и структурная кинематическая схема	(c) Тип управления	(d) Технологическое назначение
А=A	Б=B	В=C	Г=D
Электромеханический 1 Пневматический 2 Гидравлический 3	Прямоугольная 1 Цилиндрическая 2 Сферическая 3 Угловая 4	Цикловой 1 Позиционный 2 Контурный 3	1 По технологическим переделам машиностроительных и немашиностроительных отраслей
(II) Тип робота → А Б В Г			
(III) Признаки типоразмера			
(a) Главный параметр (по ГОСТ 25204—82)	(b) Параметры (по ГОСТ 26062—84)		
Грузоподъемность, (*P*), кг (c)	Наибольшее перемещение, (*L*), мм, (φ), град (d)	Быстродействие, (*t*), с, (*v*), мм/с, (ω), град/с (e)	Погрешность позиционирования, Δ, мм (f)
Типоразмер (модель) работа → А Б В Г; *P*, *L*φ, *t*υω, Δ (IV)			

Key: I--Types of Robot Features

a--Type of Drive

b--Type of Coordinate System and Structural Mechanical Diagram

c--Type of Control

d--Manufacturing Function

A1--Electromechanical
A2--Pneumatic
A3--Hydraulic
B1--Right-angled
B2--Cylindrical
B3--Spherical
B4--Angular

C1--Cyclic
C2--Positional
C3--Contour
D1--By Manufacturing Redivisions of Machine-Building and non-Machine-Building Sectors

II--Type of Robot--A B C D III--Type Size Features

IIIa--Main Parameter (re GOST 25204-82; IIIb--Parameters (re GOST 26062-84); IIIc--Load-Lifting Capacity, (P), kg; IIId--Greatest Change of Position, (L), in mm, (φ), in degrees; IIIe--High-Speed Response, (t), in seconds, (v), in mm/second, (ω), degrees/second IIIf--Positioning Error Δ, in mm; IV--Standard size (model) of robot--A B C D; P, Lφ, tυω, Δ

Table 2 presents information regarding the demand for types and type sizes for industrial robots according to type of drive and manufacturing function (all the tables have been drawn up according to data from the Council of Chief Designers of Industrial Robotics, from member nations of the Council for Mutual Economic Assistance.

Table 2: Demand for Types and Type Sizes of Industrial Robots

(I) Наименование типов ПР	(II) Количество типоразмеров, шт.	(III) Освоено и осваивается производством стран—членов СЭВ и СССР (в скобках), %
(IV) По типу привода		
1 Электромеханические	102	21 (6)
2 Пневматические	52	62 (29)
3 Гидравлические	76	42 (29)
(V) По технологическому назначению		
А. Машиностроение:		
окраска, нанесение покрытий, сварка, сборка	38	58 (34)
обслуживание металлорежущих станков, кузнечно-прессового и термического оборудования	109	57 (30)
Б. Немашиностроительные отрасли	83	2 (—)
(VI) Всего типоразмеров . . .	230	58 (34)

Key: I--Description of Industrial Robot Types
- II--Number of Type Sizes, units
- III--Council for Mutual Economic Assistance Member Nations and the USSR (in parentheses) Which have Initiated or Are In the Process of Initiating Production of Industrial Robots, %
- IV--Robot, Classed by Type of Drive
- IV1--Electromechanical
- IV2--Pneumatic
- IV3--Hydraulic
- V--Robot, Classed by Manufacturing Function
- VA--Machine-Building:
  painting, coating application, welding, assembly, servicing of metal-cutting machine tools, press-forging and thermal equipment
  non-Machine-Building Sectors
- VI--Total Type Sizes

STANDARDIZATION OF INDUSTRIAL ROBOT DRIVES

ELECTRIC DRIVES. In compliance with the technical requirements imposed on electric drives for industrial robots, the latter must be closed according to the speed at which they operate and their position, should be equipped with position sensors and must have electromagnetic brakes.

The electric drives which have been and are being developed do not fully meet the requirements of industrial robotics.

The demand for types of electric drives for industrial robots is shown in Table 3.

Table 3: Demand for Types and Type Sizes of Electric Drives for Industrial Robots

(I) Наименование типов	(II) Количество типоразмеров, шт.	(III) Освоено и осваивается производством в 1985 г., %
(a) Электропривод постоянного тока	10	(a) 70 (некомплектные незамкнутые по положению приводы)
(b) Электропривод переменного тока	10	30
(IV) Всего типоразмеров . . .	20	60

Key: I--Description of types
Ia--Alternating Current Electric Drive
Ib--Direct Current Electric Drive
II--Number of Type Sizes, units
III--Production of Electric Drives Initiated or in the Process of Being Initiated in 1985, %
IIIa--(incomplete, non-closed, according to position of drive)
IV--Total Number of Type Sizes

The 10th Five-Year Plan saw the development of nine standardized direct-current type sizes of electric drives for industrial robots, which in addition were regulated as to speed, and which had capacities* of from 25 (0.05) to 4,000 (35) watts; five type sizes of alternating current electric drives, regulated as to position using Series 4A asynchronous motors with a capacity of from 370 (2 and 3) to 3,000 (17) watts.

During the 11th Five-Year Plan, development was slated for 11 type sizes of direct current electric drive, in the range from 16 (0.035) to 3,000 (35) watts and nine type sizes of alternating current electric drive with capacities of from 90 (0.7) to 5,500 (47) watts, and regulated as to speed. Direct current electric drives having a capacity of up to 1,100 (3.5) watts must be designed to use motors equipped with disk armatures, and those with capacities of over 1,100 (3.5) watts must use motors with cylindrical armatures.

Unfortunately, the flaws found in existing electric drives make their standardization more difficult:

the direct current electric drives are the open-position type and have not been completed with position sensors and electromagnetic brakes;

the structural designs of the electric drives which have been developed to date are not standardized among the available models.

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*Values for rated moments, in Nm's, are given in parentheses.

In this connection, the problems of prospective electric drive developments take on special significance, and this includes the problems of their standardization, particularly the development and initiation of production of complete sets of direct current electric drives and fully equipped electric drive units equipped with thyratron motors and induction motors in the power range of from 10 to 7,500 watts (initial treatments of up to 1,100 watts).

PNEUMATIC AND HYDRAULIC DRIVES

Table 4 shows the demand for types of pneumatic drives.

Table 4: Demand for Types and Type Sizes of Pneumatic Drives for Industrial Robots.

(I) Наименование типов пневмопривода	(II) Количество типоразмеров, шт.	(III) Освоено и осваивается производством в 1985 г., %
a Линейные	20	100
b Поворотные	16	69
(IV) Всего типоразмеров . .	36	92

Key: I--Description of Types of Pneumatic Drives
Ia--Linear
Ib--Rotating
II--Number of Type Sizes, units
III--Production of Pneumatic Drives Initiated or in Process of Being Initiated in 1985, %
IV--Total Number of Type Sizes

One prospective direction for industrial robotics is that of positional pneumatic industrial robots. To realize this, it is necessary to develop and initiate production of the following types of equipment and drives:

air distributors with proportional electric control and pneumatic reduction valves with proportional electric control (with a 4-12 mm nominal bore, and a rated pressure of 1.0 MPa);

linear positional pneumatic drives (with up to 1,600 mm of travel, a working speed of up to two meters per second and a rated pressure of up to 1.0 MPa;

rotating positional pneumatic drives (with up to a 310° angle of rotation, up to 400 Newton·meters of torque and a rated pressure of 1.0 MPa.

The primary direction by which the basic indicators for hydraulically-driven industrial robots might be improved is the improvement of the hydraulic equipment and robots with contour control, which need to have production of the following types of hydraulic equipment and drives developed and initiated:

longitudinally stroking hydraulic cylinders (with a piston diameter of 12-80 mm, a stroke of up to 1,600 mm and a rated pressure of up to 16 MPa);

completed hydraulic linear servo drives (with a stroke of up to 1,600 mm, a speed of up to 1.5 m/second and a rated pressure of up to 16 MPa);

same as above, with rotary motion (with a rated pressure of 16 MPa and a working volume of up to 125 cm^3/revolution).

STANDARDIZATION OF CONTROL UNITS

The control units (UU) which have been developed to date are intended for the most part to control individual types of industrial robots, and it is for this reason that developments and production of control units continues to be carried out by the ministries which develop industrial robots. At present, there are eight models of standardized control units for industrial robots in production. Control unit development should be done on microprocessors and on microcomputers using modern large-scale integrated circuits with large memory capacity which are indestructible as a result of power shutdown, and equipped with function generators and other electronic devices.

In order for the 12th Five-Year Plan period to witness the development of basic modular cyclic-grouped and positional-contour types of control units, and adaptive control units with technical viewing, force-moment, tactile (with and without contact) sensitivity, we need to develop the following control unit models:

processors (one or several, 8- to 16-bit models, etc.);

103U, PP3U, P3U and other memories;

input-output discrete signals;

interface capability for linking up with peripheral units (radial-sequential interface);

pairing with units having external memory (storage on floppy disks, magnetic tape etc.);

operators' consoles;

training and manual control consoles;

engineering consoles;

power feed systems;

pairing with higher-level computers and with other control units;

pairing with drives (including sensor signal conversion and control of motion coordinate drives);

analog computer input (from adaptive equipment and monitoring and testing equipment) and standardization of electronic sensing devices.

In addition to standardizing industrial robots in accordance with the modular principle, the mathematical software must be standardized, and modular mathematical software systems developed during the 12th Five-Year Plan period as well.

STANDARDIZATION OF INDUSTRIAL ROBOT DESIGN

In the course of design standardization, we recognize two primary methods of constructing robots from standardized subassemblies, hereinafter referred to as modules.

One of the methods is based on production robots made up of modules which corespond to the purpose of the design's functional subassemblies, for example the modules for turning, lifting, thrusting out ("hands") and oscillation.

The enumerated units perceive the power demands on planes determined by the functional designation of the above-named units.

Both domestic enterprises and foreign firms have used this method to create modular designs.

Figure 1 shows the essence of this method of designing.

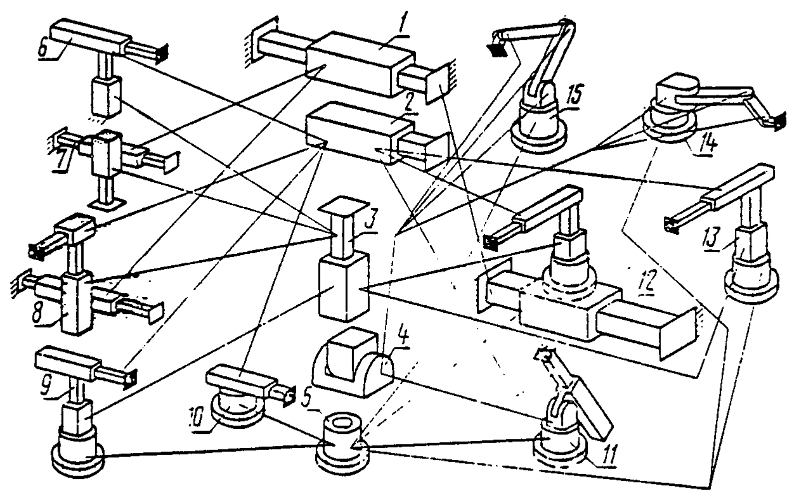


Figure 1: Standardization of Industrial Robot Designs By Using Modules for Lifting, Turning, Extension and Oscillation.

Key: 1--Change of Position; 2--Thrusting Out; 3--Lifting; 4--Oscillation; 5--Turning. Modular Industrial Robots: 6-8--Operating at Right Angles; 9, 10, 13--Cylindrical; 11--Spherical; 12 and 14--Combined; 15--Angular Coordinate Systems

The second method is based on the principle of designing industrial robots from modules which are compatible to the purpose of the subassemblies of the structural kinematic diagram, both rotary and forward-moving (independent of their spatial position).

These units can perceive power demands no matter what the spatial position of the modules.

This method, which is used in the TsNIIRTK (in Leningrad), is the most commonly used with regard to the first, and permits the arranging of industrial robots from a limited number (compared to the first method) of type sizes of modules, and allows the latter to be utilized as independent units while the robot-equipped manufacturing complexes are being set up.

The essence of this method of designing is elucidated in Figure 2.

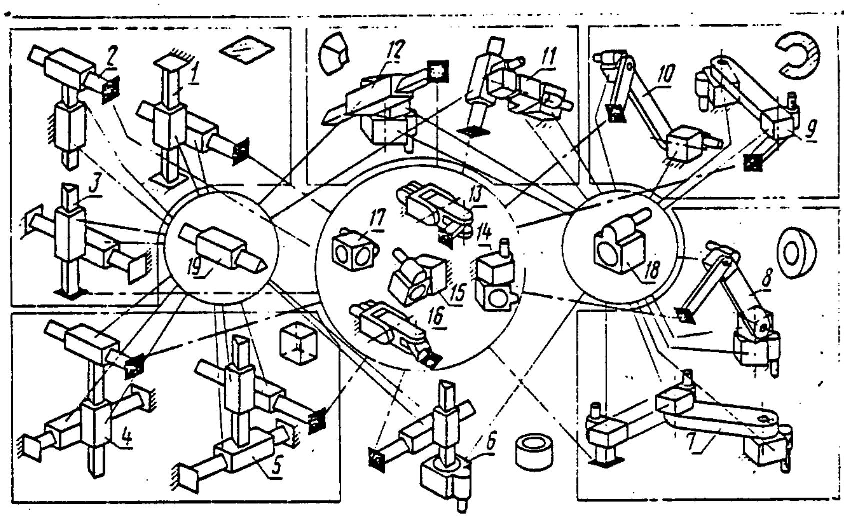


Figure 2. Standardization of Industrial Robot Designs Through the Use of Rotary and Forward-Moving Modules:

Key: 1-5--Modular Industrial Robots Which Operate at Right Angles; 6--In the Cylindrical; 7-10--In the Angular; 11,12--In Spherical Coordinate Systems. Modules (units): 13-17--Two-Stage; 18--Rotary; 19--Forward-Moving

UDC 006.015.2:658.516:007.67:65.011.56

Aggregated, Modular Robot Systems

Moscow STANDARTY I KACHESTVO in Russian No 5, May 85 pp 28-29

[Article by V. B. Velikovich of ENIMS (Experimental Scientific-Research Institute for Metal-Cutting Machine Tools: "Unification and Standardization of Industrial Robots in Minstankoprom (Ministry of the Machine Tool and Tool-Building Industry)"]

[Text] the tendency to use the aggregated-modular system of designing PR [industrial robots] has become characteristic of present-day robot building. In all probability, this same principle should be used to devise GPS's [flexible manufacturing systems]. The aggregated-modular principle, which is based on unification and standardization, should become the basis which will insure effectiveness in flexible manufacturing systems on a different integrated level.

And indeed, the setting up of flexible manufacturing systems, where components can be machined in individual lots, is extremely costly. And only unification and standardization can make it possible to reduce the products list of components and system subassemblies, with practically no limit to variety in the nomenclature of manufactured products.

Standardization and unification are important as well when setting up maintenance procedures for industrial robots and for operational flexible manufacturing systems. The local regional maintenance services should have a simple enough time of organizing the suitable capacities which will provide the clients with spare parts for the operating robots.

Minstankoprom [Ministry of the Machine Tool and Tool Building Industry] is presently making a major effort to standardize and unify industrial robot integrated machine sets and modules. The new range of robots which are to be manufactured during the 12th Five-Year Plan period will be built according to the aggregated-modular principle. At present there are already a great number of design resolutions which have been made standard features of all production models. Primarily this concerns the standardization of connection points, grabbing devices and drives.

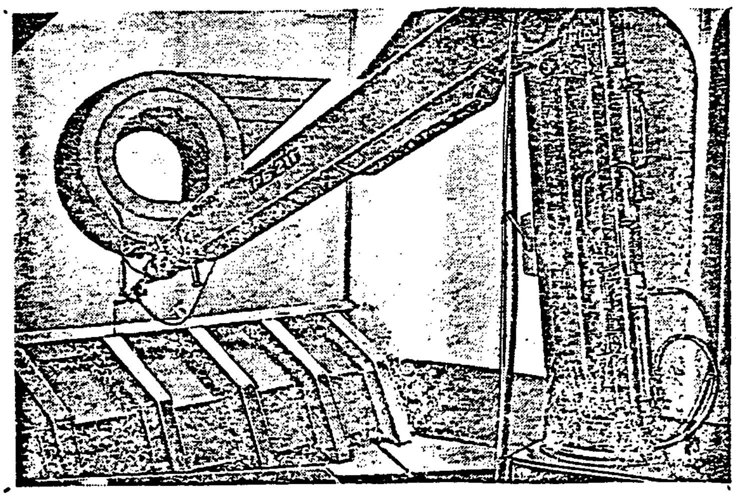
The range of robots being produced at the Mukachevo Machine Tool Works has, thanks to the aggregated-modular principle, seven models at present. They have developed a conception of aggregated-modular construction of industrial robots for forge-pressing equipment.

Nevertheless, the greatest effect to be derived from unification and standardization in our opinion, will come only at such time as, in the course of solving problems associated with organizing series production of varying industrial robot models, the task of using the minimum number of parts, subassemblies and assemblies to make the maximum number of industrial robot models, is undertaken.

At the present time--and this is common knowledge--there are a great number of same-type robot models which are duplicating each other's functions, and these robots are being manufactured by different ministries and departments, but there is no sort of centralized monitoring of the problems of unification and standardization. Without a doubt, this situation cannot be allowed to continue.

In its role as the main ministry for robots used in machine-building, Minstankoprom has been charged with conducting an analysis of the industrial robots now

being produced for the purpose of eliminating their being duplicated. Evidently it would be advisable, within the framework of the work now being done, to try to solve the problems of unification and standardization. But for this to come about, Gosstandart [State Committee for Standards] needs to participate on an active level.



The RB-211 industrial robot, with programmed control. This unit serves to automate painting and enameling operations, and the application of thermal-insulation and other types of coatings. Number of degrees of motion--6, number of executable commands--75, positional accuracy--3 mm.

There are efforts being made within the framework of the Council for Mutual Economic Assistance for the standardization and unification of robots. A plan has been devised for standardizing the varying elements of robotics. A number of standards have been drawn up and are now being examined. Minstankoprom is maintaining bilateral contacts with the member-nations of the Council for Mutual Economic Assistance to come to a state of concord regarding approaches to the problems of the standardization and unification of robots.

It appears that the most important problem will concern development of the prospective standardization of the industrial robots being produced by the Council for Mutual Economic Assistance member-nations. In all probability, special emphasis will have to be put on reducing the products list of industrial robots. And then, after having determined the manufacturer-countries of those or other models of industrial robots, conditions should be formulated for the unfailing delivery of those robots ordered by the countries and for the prior stipulation and determination of their cost, i.e. there must be a pertinent price handbook available, the propagation of which must have been effected, if only for the five-year plan period. With standardization clearly regulated, it will be possible to develop an appropriate range of units, assemblies and models, on which basis industrial robots can be developed for the purpose of setting up mutually cooperative deliveries.

It might be especially worth noting that standardization calls for a serious, thoughtful and cautious approach. Badly thought out solutions will turn standardization into a brake for progress.

In this connection I should like to emphasize the need for a thoroughgoing preparation of the overall basic standards, for example, the terminological standards.

Today we have a standard for the terminology and definitions used in the field of industrial robot production and operation. But its state of imperfection has already become evident. For example, this standard has no such term as "control computer" [avtooperator]. Nor do we have definitions for "automatic transfer line", "versatile transfer line" or "rearranged transfer line". All these things lead to such negative consequences as confusion in the bookkeeping.

In this connection, it would be desirable for the NTS [Scientific-Technical Council] Section on Standardization in Robotics to come out with an initiative concerning the development of a correlating standard for terms and definitions with regard to automation equipment. It would be advisable as well for the development of an industrial robot products list to be preceded by a working conference on robotics, wherein the primary participants would have to be the customers for industrial robots and their manufacturers. This will permit us to carry out our unification and standardization efforts more effectively and purposefully.

UDC 007.52:65.011.56:658.511.4.012.1

Specialized Robots for FMS

Moscow STANDARTY I KACHESTVO in Russian No 5, May 85 pp 29-30

[Article by A. G. Baranov, candidate of technical sciences: "Robots for GPS's (Flexible Manufacturing Systems)"]

[Text] Industrial progress is closely connected to the development and widespread application of new and promising systems for the comprehensive automation of manufacturing systems--the GPS's, or flexible manufacturing systems. The distinctive features of GPS's are their high degree of self-regulation and stability as they function in manufacturing conditions wherein a great number of products are used, with simultaneous high-speed readjustments, their high level of organization in the functional medium and their high degree of automation at all stages of the product-making process (designing, manufacturing design and manufacturing itself).

The structural logic of these systems requires a reorganization of the established manufacturing structures, the widespread use of PR's [industrial robots] within these structures, ATNS's [automated storage and transport system], equipment with NC, automated control equipment, microprocessors and computers, and RTK's [robotics complexes] which in the aggregate provide, as required by the manufacturing conditions, organization of the informational and material connections, as well as the production flow lines in an automated system.

As a rule, robotics complexes are self-contained manufacturing units, and as part of a flexible manufacturing system, can act as production modules or production lines, including those which function autonomously. In the latter instance, robotics complexes serve essentially GPM's [flexible manufacturing module] or GAL's [flexible automated production lines], which are made up through the use of industrial robots.

The construction of flexible manufacturing modules and flexible automated production lines using industrial robots can be done in the manufacturing, assembly (plant), welding-assembly and other industries. The primary problems which arise from the inclusion of robotics complexes in flexible manufacturing systems are associated with providing functional autonomy and reliability in automatic operating conditions and while operating under the control of a central computer in an automatic readjustment mode.
Autonomy can be achieved in a robotics complex by making a memory part of its makeup and by increasing its stock of manipulative tools.

The achievement of a tolerable level of reliability in the operation of a robotics complex is a more complicated problem. Such a complex has to operate breakdown-free without human assistance during a single shift, with a 90 percent probability of success. Since the cause for a breakdown in a robotics complex can be the breakdown of any of its integral parts (machine tools, individual industrial robots, accessories etc.), as well as a manufacturing failure connected with incorrectly functioning equipment and the appearance of defective products, then the overall number of unrelated sources of breakdowns even in a small complex can reach 10 and more. In connection with this, the operating time they accrue prior to breakdown should be on an order higher than for robotics complexes overall. To date this problem has not been completely solved. That is why, in order to achieve the required indicators for operational fitness in the robotics complexes, we need to utilize the principle of comprehensive provision of reliability, which is based, first of all, on structural methods.

The establishment of the most reliable robotics complex structures is associated with reductions in the products list, standardization, the provision of functional and dimensional interchangeability in the automation equipment being used, the application of the modular principle to the construction of all constituent robotics complexes and the principle of module-duplicating redundancy in their component parts. Widespread utilization of methods and equipment to diagnose the technical condition of robotics complex elements, as well as their protection from breakdowns and their adaptation to changing operating conditions. One of the conditions for improving the reliability of robotics complexes is to devise new technical automation equipment, which satisfies the requirements for functional completeness, compatibility and integration of the prescribed set of configurations into the flexible manufacturing system. Thus, robots intended for use in flexible manufacturing systems for the purpose of reducing the products list of various automation devices must do the following:

loading and unloading of manufacturing equipment, including monitoring equipment;

reorientation and interoperational movement of parts;

servicing of memories;

removal of machining wastes from the bases of parts and attachments;

loading and unloading of tool stocks;

control of robot equipment and attachments;

monitor the paramaters of the parts with the help of built-in monitoring and testing equipment;

monitor tool condition;

see that the workpieces are available and are in correct position to be worked;

monitor the correctness of the accessory tools and the complex's auxiliary units;

automatic replacement of operating mechanisms, i.e., carry out an expanded range of functions.

Robots must also satisfy conditions for the most favorable pairing with the servicing equipment for the kinematic structure, the information and logic structure of the functioning algorithms, the load-lifting capacity, precision, speed of response, and the design and power engineering informational parameters. These conditions are determined during the design stage for specific flexible manufacturing systems and call for the specialization of industrial robots.

The requirement for robots to be specialized is in contradiction to the requirements for unification, reduction in the products list of models, and hence, with the requirements for increasing their universality. The contradiction mentioned above is characteristic as well for other automatic machines, and that is why it gives rise to a problem associated with the design of technical automation equipment for flexible manufacturing systems. This problem can be solved by constructing functional equipment subsystems in line with the self-contained module principle, which allows the structure, the design, as well as the functions and characteristics of the automation equipment to be changed and improved as new problems for them to solve come along.

One of the problems which has been found difficult to solve is the automation of readjustments of the robotics complex. Full automation of these adjustments is far from being always feasible, inasmuch as the series-produced equipment and robots, which are the basis upon which present-day robotics complexes are constructed have not yet been adapted for use in flexible manufacturing systems and have limited potentialities regarding automatic readjustment. They lend themselves to automation only with difficulty for operations such

as adjustment of the tool, the monitoring devices, the varied attachments, the cutting-oil feed system and shavings-removal devices.

In order to achieve sufficient flexibility in robotics complexes for readjustment, the following conditions need to be fulfilled:

set up group manufacture of products;

use automatically readjusting automation hardware components;

use high-speed readjusting all-purpose auxiliary equipment and attachments;

insure invariance in the structure and basic features of the robotics complexes with regard to replacement of the workpieces and the pattern of production.

Fulfillment of the above-enumerated conditions is associated with major difficulties. First of all the difficulties involved with providing a high level of organization in group manufacture in situations where destabilizing factors disrupt the plans for the start-up of production of manufacturing groups of parts and lead to frequent disruptions in the material and informational connections between the flexible manufacturing systems which comprise the structure. Moreover, new and reliable control systems need to be devised for flexible manufacturing systems.

The control systems for flexible equipment have to have standardized interfaces for the connections among themselves, with the maintenance processes and with the upper-level computer. An energy-independent memory must be used in order to preserve the library of working programs within the equipment. Moreover, they must possess the capability of having blocks built into them which will make it possible for their hardware components to adapt to changes in the external surroundings. The visual displays, the keyboard and the systems' program software modules must make possible the programming, monitoring and editing of the operational program and diagnosis of the technical condition of the automation equipment in the dialog mode by the least labor-intensive method.

Thus, the setting up of flexible manufacturing systems still requires the solution of a number of problems.

Outlook for Standardization of Robots

Moscow STANDARTY I KACHESTVO in Russian No 5, May 85 pp 30-31

[Article under the rubric "Decision of the Gosstandart Scientific-Technical Council": "The Further Development of Work on Standardization and Metrological Software in Robotics"]

[Text] At the joint session of sections of the Gosstandart Scientific-Technical Council, which was entitled "Industrial Robots and the Equipping of

Production Complexes With Robots" and "Metrological Software", and which was held on 18-19 December 1984 in Leningrad, the problems of the status and direction of efforts toward standardization of robotics during the 12th Five-Year Plan were taken under consideration, as was the subject of metrological software.

At the meeting of sections it was noted that in accordance with growth trends in the national economy of the country, GPS's [flexible manufacturing systems] are undergoing considerable development at present. The technical basis for the comprehensive automation of production consists of robotics modules, computers of varying levels of control and automatically operating measuring equipment.

In carrying out the tasks set by the 26th CPSU Congress and in the decree of the CPSU Central Committee and the USSR Council of Ministers, which was entitled "Measures for Accelerating Scientific and Technical Progress in the National Economy", Gosstandart, along with the ministries and departments, have developed and are in the process of realizing a scientific and technical program for the development of industrial robots, which has been approved by the GKNT [State Committee for Science and Technology], USSR Gosplan [State Planning Committee] and the USSR Academy of Sciences, as has a program for the comprehensive standardization of industrial robotics, which program includes the drawing up of 139 normative-technical documents, including 55 state standards. At the present time, 14 basic state standards have been approved; methods have been developed for the checking, without dismantling, of nonelectrical quantity systems by sensors built into the units; contact-free electrophysical sensors of nonelectric quantities, which are stable in the changing and extreme conditions of flexible manufacturing systems have been developed, as has a procedure for analysing metrological software for flexible manufacturing systems.

As the first stage of the country's efforts to aggregate industrial robots, VNIINMASH [All-Union Scientific-Research Institute for Normalization in Machine Building] has developed a plan for a system of aggregated modular construction (SAMP) for industrial robots.

A program of efforts regarding the normative-technical maintenance of the system up to 1990 has been approved. This program has been made an addendum to the Program for Comprehensive Standardization of Industrial Robots.

Thus, during the 12th Five-Year Plan period, state standards for robots of the aggregated-modular design are to be developed in our country for the first time.

At the same time, it was noted at the joint session of the Gosstandart Scientific and Technical Council sections that there are still a number of failings in the designing and production of industrial robots.

As has been demonstrated in practice, the aggregated-modular design principle has found little use in the development of industrial robots, and the same holds true for standardized drives, holding devices, sensors and other of the parts which make up these robots.

A major failing is the absence of an organized sequence for testing industrial robots and their components: no main organization has been specified; the testing laboratories which are to conduct the industrial robot tests at the manufacturing enterprises have yet to be certified; no standardized testing procedures have been worked out; there are no standardized equipment or sensors and there is no MO [metrological software] program for robotics equipment.

The sections point out that the main trend in metrological software for flexible manufacturing systems and robotics is that of having the metrological software built into the flexible manufacturing systems which are now operating at all the technological stages of the manufacture of automatic control systems, which is in accord with the set requirements for both manufactured products and manufacturing routines of both tools and attachments, not to mention automatic monitoring and diagnostics for the elements of flexible manufacturing systems and robots even as they operate, which will insure their fitness for operation as well as precision in their carrying out of prescribed operations.

From this point on it would be well to think of the questions of metrological software for robotics as an inseparable part of the overall program for metrological software for flexible manufacturing systems, and to think of them not only in scientific, but in organizational terms as well.

In the decision adopted by the Scientific and Technical Council, it is pointed out that in order for the efforts to standardize robotics to continue developing, the main direction for this development ought to be unification and standardization using the aggregated-modular principle of designing robotics equipment, which will make high-speed readjustment in industrial robots a real possibility applicable to a variety of equipment types. This feature ought also to be built into robot-equipped manufacturing complexes and flexible manufacturing systems designed for varying purposes. In connection with this, the Technical Administration, the Administration of the Machine-Tool Industry and the intersectorial industries of Gosstandart and VNIINMASH ought to include the development of a system for aggregated-modular industrial robot construction in the schedule of work to be accomplished during the 12th Five-Year Plan period. The schedule ought to include the development of:

a range of standardized programmed control systems;

standardization of basic industrial robot models;

collections of kinematic units (modules);

standardization of unified holding devices;

standard set-completing elements (electric, hydraulic and pneumatic drives; electric, hydraulic and pneumatic automatic equipment) and sensors for industrial robot information systems.

The machine-building ministries have recommended the carrying out of a number of measures which will greatly improve the reliability of robots and basic set-completing items, industrial robots and flexible manufacturing systems.

Gosstandart institutes, along with TsNIIRTK have been charged with conducting an analysis in 1985 of the status of metrological software used in the development, manufacture and operation of robotics equipment. Using the data derived from this analysis, they are to work out a suitable comprehensive program of operations to be made an integral part of the program for the comprehensive standardization of industrial robots.

It has been recommended that Minstankoprom select a main organization in 1985 which will conduct state tests of industrial robots, and in this connection Minstankoprom is to approve the Decree on the Sequence for carrying out the tests, as well as the certification and evaluation of the technical level of the pilot models for industrial robots and their standardized components.

The Scientific and Technical Council noted that 1986 would be a good year for conducting scientific and technical conferences: one to be devoted to problems of reliability and metrological software for industrial robots and flexible manufacturing systems, the other (conducted conjointly with the VSNTO [All-Union Council of Scientific and Technical Societies]), to be an all-union conference, dedicated to modular equipment construction.

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ROBOTICS

PROBLEMS WITH ROBOTIZATION OF CONVENTIONAL SHOPS

Tashkent PRAVDA VOSTOKA in Russian 14 Jul 85 p 2

[Article by V. Chernomorskiy: "Robot Hasbeens" under the rubric "As Revealed by the Experiences of the Tashkent Tractor Plant imeni 50th Anniversary of the USSR"]

[Text] These are not robots from a children's technical creativity display, with indicator eyes and magnetically recorded "How are you?" These are workhorses--industrial robots which stoically transfer stock from one machine to another and lay aside the finished products in the workshop of the Tashkent Tractor Plant. The time has come to decide where they are to "live", how to gain more use from them, how to introduce them more widely at industrial enterprises.

The Environment

Robots are needed where conditions are hard for man: in hot shops, unhealthy or tiring monotonous industries. Is this the case of shop No. 126, robotization complex, as it is known at the tractor plant?

"Yes and no," responds V. Demidov, shop foreman. "Robots have freed workers from uninteresting, unproductive transport jobs, leaving behind qualified maintenance personnel. Even so, there are many processes at the plant where robots are much more needed. We used what was available, and nothing more."

There are five robotized lines in the complex. They produce parts of eight types: transmission shafts, the covers of bearing assemblies, the bodies of the trailer switching crane. Just eight out of a nomenclature of many thousand, but even these were hard to choose. The group of engineers headed by V. Levitskiy, assistant chief technologist of the association, had much to do in order to coordinate the specifications of the robots and machine tools and the unified operations chart of the plant. The complex of 24 machine tools works efficiently on the tractor production program in two shifts.

It is attended by Vasiliy Petrushin's brigade of 17 workers: half of them troubleshooters, half operators. There are six machines for each operator. The labor productivity has increased by two-three fold. Not bad?

"Don't be fooled" warns Vladimir Ivanovich. "The other side of the coin is that the troubleshooters also have to be 'supported' by the manufactured products. And there's also a startup engineer group to help the brigade."

[Question] But on the whole?

"On the whole, considering the cost of the robots and their lifetime, the complex is a luxury. But it was worth it to 'start the garden.' The experience with the complex has pointed out the main directions of automation and robotization of the industry. The first cadres of troubleshooters have been trained."

There are few NC machines at the plant. These are not so essential, because there is no frequent change of product or retooling. The majority of the technological lines are fixed, with aggregated machines designed to produce only one part. If the assembly conveyor needs the part, the machine works. If there is a surplus, it stops. The standstills of the transport robots at these machines are costly.

"There is a solution," says V. Levitskiy. "But we need aggregated machines with automatically-interchangeable machining heads. Unfortunately, our main supplier, the NPO [scientific production association] Tekhnolog, does not make such machines. But it is high time! Robotized lines with such machines and a machining center appear to be the industry of tomorrow."

[Question] But for now?

"For now we are searching for an economic impact in the concentration of robots on the principle: one robot is bad, ten begin to make sense, 100 are good. 100 robots in a shop can be attended by a single brigade, paid for by the end products. In this way we are organizing the 28th shop, which makes gears. Another avenue is the rapid assimilation of not only manipulators, but also robots performing the primary technological operations. Steps have already been made in this direction: in shop No. 16 they will be painting the cabins of the tractor, in shop No. 26 the transmissions. Next in line are welding robots. And here, perhaps, there will be a direct economic and social impact.

The Need for New Thinking

A robot is an expensive "creature." But it will be two or three times more economical in mass production. It will replace people; in the language of the economist, it will become an active part of the primary resources. So the "insides" of the shops will be changed, but what about their form? Shops that will last for 25-50 years will continue to be built and designed for people to work there. The sanitary and other regulations dictate a structure of 7-9-12 meters height, of which a maximum of two are used.

Is this many-meter margin necessary? To robots it is all the same whether they are working on the horizontal or the vertical, nor do machine tools require special conditions. Perhaps the main impact of robotization may be achieved by a three-dimensional layout of the technological lines and maximum "packing" of the structures with mechanisms along the entire height. Such is in fact the layout of the chemical industries, which operate without human involvement.

When designers develop a new part they consider how easy it is to produce. But it is now time to check each part for "robot-friendliness" as well. In other words, modern enterprises should establish a clearcut sequence: designer-product-machine-robot.

Consider how a robot services a machine. It takes a piece of stock, inserts it into the machine and waits until the machine cuts a face or bores an opening. It waits for one minute, two, five. Its program depends on the output of the machine. If the machine were faster, the robot would not have to wait. But if the speed is increased, the cutters or drills would "fly off." The robot requires a technological innovation: laser, plasma or some other.

"Some would like to incorporate the robot in the presentday 'man/machine' system," says Yu. Ivanov, chief of the robot engineering bureau of the plant. "But we are convinced that this will not happen. Robotization requires a quest for new manufacturing principles."

A recent conference at the CC CPSU on questions of accelerating the scientific and technical progress did in fact call for scientists and engineers to repudiate many of the presentday stereotypes and enunciated that our primary obligation is to learn to think differently.

Who are the Comissars of the Scientific-Technical Revolution?

Given a scientific-technical revolution, it should also have its comissars, those who radically reject the obsolete, who firmly know what to do. The tractor plant is being robotized at its own cost and risk, by the method of trial and error. The same is true of the Tashkent aviation plant. Isolated "episodes" of robotization are also discerned at other enterprises. But for now they are all on a "self-supporting" base.

Only the Tashsel'mash, it seems, has tackled the matter in a scientific way: it ordered a cold plate stamping flow line from the NPO Kibernetika, paid several hundred thousand rubles for the research, but after receiving the project it immediately grasped that this was an idle daydream.

But the overwhelming majority of enterprises are not thinking about introducing robots and do not know where they might be used. As a result, of the 1000 robots earmarked for this five-year plan by the Gosplan of the republic around 200 are in use.

Thus, who are the comissars of robotization? Who points the way to the seeker and prods the dawdler? It has been assumed that the NPO Kibernetika would take on this function. A special group of three (!) persons has even been created there.

Excuse me, but three people are not enough. All the enterprises must make a detailed investigation and discover areas where robots should be introduced. We need proposals and projects, economic ones, of course, based on familiar analogs, and not newly-invented "wheels" for hundreds of thousands of rubles. The republic also lacks up-to-date information about robot engineering. This should be collected at some place and disseminated by someone. Finally, someone should help in the assembly and start-up of the robotized lines.

"We must create a republic scientific-technical coordination center for the intensification of the industry" believes N. Muminov, deputy director of the NPO Kibernetika. The same concept has been advanced at the tractor plant.

A slight correction is warranted: not just another organization formally responsible for everyone, which means for no one. Let this be a self-supporting enterprise, so that its specialists form a liaison between the industry and science, the robot manufacturers and designers. Let them have an interest in the end result. The center, incidentally, may be instituted on a shared basis of flexible automated interindustry production, the effectiveness of which has been proved by the experience of Moscow and Leningrad.

The creation of such an organization would be in the spirit of the demands raised at the conference of the CC CPSU. And the center should receive its operating funds from its client enterprises, as a deduction from the achieved economic impact.

Yet Another Problem

Robots replace people. But people continue to work with them: higher-level professionals. At the TTP, for example, the brigade has three with higher education, the others have secondary technical education; the startup group has three with technical secondary education, the others have higher education. Everyone is an electronics technician, electrician, mechanic and hydraulic engineer. At the same time, everyone is also a practicing robot engineer. But no certified specialists are being trained anywhere in the republic.

While it is true that the Tashkent Polytechnical Institute has a department of "Robot Technical and Information Systems," no one has yet received a robot engineering degree there. The Ministry of Education is not planning a graduating class in this specialty, despite the many proposals of the faculty. It is argued that no requests for robot engineer staff have been received from the enterprises.

But perhaps the ministry is living in the past and can no longer look to the future? For the hypothetical center itself requires no less than 100 engineers, and each factory will require three or four from the outset.

Whether we like it or not, robots are here to stay. They signify an industrial advance to a new technological and engineering level. Perhaps they are now becoming the catalysts of scientific and technical progress at the enterprises. And we have no time to vacillate.

12717
CSO: 1823/214

ROBOTICS

UDC 621.757(088.8)

ROBOT CONTROL SYSTEM MODIFIED FOR PRECISION MOVEMENT

Moscow IZVESTIYA VYSSHIKH UCHEBNYKH ZAVEDENIY: MASHINOSTROYENIYE in Russian No 7, Jun 85 pp 140-143

[Article by Candidate of Engineering Sciences P. M. Kuznetsov and post-graduate student M. L. Popov: "Expansion of the Technological Potential of Industrial Robots for Doing Assembly Work Under Flexible Automated Production"]

[Text] Questions of automating the robotized assembly of precision cylindrical joints under flexible automated production (GAP) are examined. As indicated by research that has been performed, precision in the positioning of existing robot designs does not enable the indicated operation to be performed under GAP conditions.

The authors examine the potential of using additional devices with a view to resolving this task. A specific route is proposed. An arrangement that provides for precision in the motion of mated surfaces is examined.

The main demands made on industrial robots (PR's) for assembly during flexible automated production (GAP) conditions is the execution of a large number of industrial tasks, which is made possible by the creation of PR's with broad industrial potential. Existing serially produced PR's have limited industrial possibilities, improvement of their certified characteristics (raising the precision of positioning, increasing rigidity and improving the dynamic characteristics) being a complicated task from the technical and the economic points of view. A promising field is expansion.of the PR's industrial potential by introducing supplementary technical devices into the structure of robotized assembly complexes (RSK's). These installations should meet the following basic requirements:

--provisioning of a high level of reliability for assembly systems with PR's during fulfillment of the industrial task that has been assigned;

--modular design, which permits rapid resetting to various operating conditions as well as responsive restructuring for the solution of various industrial tasks;

--simplicity of mating of the basic PR control system with the overall system for controlling the industrial process;

--simplicity of design for manufacture and operation; and

--small size and weight.

An analysis of the prerequisites for assembling members of general machine-building articles, using PR's as the performing devices, indicated that change in the mutual position of the mated surfaces of objects to be assembled should be controlled by controlling change of the value of the basic assembling force. In order to realize this method, a complex of devices is required which: measures the basic forces of assembly; evaluates the mutual position of the objects to be assembled; analyzes the readings of the information sources (sensors for measuring the basic forces of assembly and sensors for evaluating the mutual position of objects); moves objects with precision; controls the motion of objects; connects the implementing devices enumerated above; and connects the RSK control unit with the control systems which provide for functioning of the assembly system under GAP conditions.

Taking into account the requirements mentioned above, the laboratory of the "Technology of Mechanical Assembly Production" department of MVTU [Moscow Advanced Engineering University] imeni N. E. Bauman developed a series of multiple-function assembly devices (a self-setting robot head (SGR) of various designs). A scheme for one of the variants is shown in figure 1.

The SGR is a tactile sensor intended for equipping a PR for GAP conditions. The mechanical portion of the SGR is a mechanism with six degrees of mobility. Motion along the XY axis and turn relative to the OX and OY axes are registered by the sensors and recorded by electric-magnet brakes. The SGR is of modular design. Various combinations of components and parts enable the following modes to be accomplished: passive elastic compensator, "hunting," and directional search. All this will enable fairly broad industrial possibilities to be obtained: the assembly of cylindrical joints with small clearances guaranteed, with restricted dimensions of the objects' chamfers, and entirely without them, and with comparatively large values of initial linear and angular errors of mutual positioning of the objects in the assembly area. The main factor that determines the SGR's industrial potential is a minimal amount of programed stepped motion of the SGR elements, and, together with them also of the object being assembled, along the OX and OY axes in the plane of assembly (figure 1).

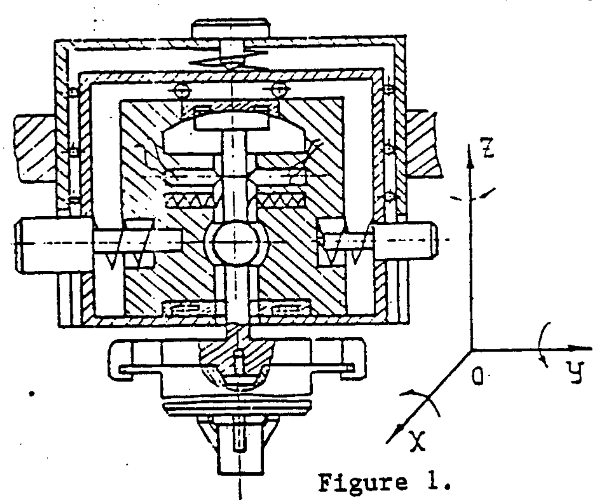

Figure 1.

The SGR's design enables both the potential of the PR itself--the assembler and the special precision drive mounted on the head itself--to be used for these motions. It was already noted above that the PR's potential is limited. For example, the best models of foreign assembly PR's, the Sigma MTO and PRAGMA-3000 of the Italian firm Olivetti and of DEA, have minimal value of programed motion on the order of ±0.1 mm, which does not provide for high reliability of assembly systems with robots of this type, even when assembling cylindrical joints with 0.05 mm clearance.

The traditional drives, which provide precision motion with stepping motors and with DC electric motors, are complicated and expensive, are rather heavy, and, as a rule, do not yield resolving-power values of less than 30-50 micrometers, which are inadequate for resolving many of the industrial tasks of automatic assembly.

The search for a drive that is acceptable for solving the assigned tasks has led MVTU manufacturing engineers to high-precision vibration-motion transformers--vibrator motors (VD's), which were developed by the Vibrotekhnika Laboratory of the Kaunas Polytechnical Institute. The small dimensions and weight, the small value for guaranteed minimum motion (less than 0.01 mm), the small time constant (less than 1 microsecond), and self-braking in the absence of a feed voltage--all these insure high promise for the use of the vibrator motors as drives for precision motion of SGR elements.

Because the RSK should function under GAP conditions, much attention was devoted during development of the VD control system to meeting the requirements indicated above. When the electronic scheme was being devised, the undesirability of using control-signal wave shaping in the form of an alternating voltage of harmonics shape in the initial stages was considered. Constructing the scheme as a functionally finished microprocessor unit allowed integrated logic microcircuits to be used and enabled the scheme to be built easily into the overall scheme for the RSK control system.

The basic job of the microprocessor is to shape the output signal for powering the VD. In so doing, three conditions for its operation were provided for. The first is uniform motion of the work object at a certain prescribed value of ΔL. The second is maintenance of the work object in the prescribed position. The third serves to provide free travel for the work object (for example, during VD operation along another coordinate).

The indicated conditions are provided through change of the output-signal frequency. The basic frequency is the VD's natural frequency. The amount of motion provided by the VD is determined both by the VD's design parameters and the control-signal parameters. The amount of motion ΔL which the VD provides can be found by the formula

$$\Delta L = F_p \Delta t \ell,$$

where F_p is the resonance frequency, which is determined by the VD's natural frequency; Δt is the period of voltage feed of the frequency indicated above to the VD, and ℓ is the VD's reaction to a single pulse.

Free travel of the work object is provided through feed of the control signal, whose frequency differs considerably from the resonance frequency. The

authors used a frequency half as great as the resonance frequency, the processor circuit being constructed in such a way that the indicated relationship is provided automatically for any resonance frequency.

Figure 2 shows a general block diagram for the microprocessor unit. The microprocessor unit has a flexible algorithm for functioning that can be changed by feed of the appropriate command information from external control devices.

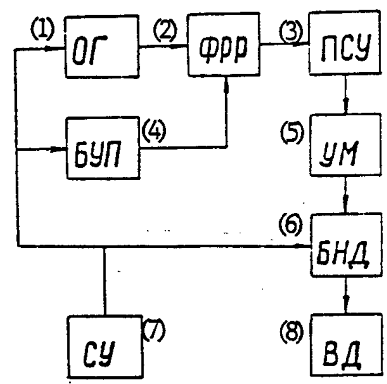

Figure 2.

1. OG [reference signal generator].
2. FRR (operating mode former].
3. PSU [control signal converter].
4. BUP [motion control unit].
5. UM [power amplifier].
6. BND [direction-of-movement control unit].
7. SU [control system].
8. VD [vibrator motor].

The reference signal generator (OG) shapes the pulses, the repetition rate of which is determined by the VD's natural frequency. The motion control unit (BUP) forms the signal which, by acting on the signal from the OG to the operating-mode former (FRR), determines one of the VD operating conditions indicated above.

The signal formed arrives at the control signal converter (PSU). Here the control signal is converted in such a way that the pulses that comprise it acquire a duty factor of two, enabling odd harmonics to be excluded from the VD's control signal. In so doing, as experience indicates, this achieves the smoothest and most economical VD operating regime.

The power amplifier (UM) amplifies the weak signal formed by the microprocessor to the value needed to power the VD. The amplifier cascade is constructed on a push-pull amplification circuit which works in class C. Here the pulse is converted into a harmonic signal.

The direction-of-motion control unit (BND) reverses the SGR elements in a linear direction during motion of the mobile elements.

Overall microprocessor control is exerted either from the manual unit for controlling operating conditions or from the overall control system (SU).

Conclusions

1. In order to automate the assembly of precision cylindrical joints, assembly robots must be equipped with supplementary devices.

2. In order to support robotizing of precision cylindrical joint assembly under GAP conditions, a self-setting robot head with microprocessor unit can be used.

11409
CSO: 1823/229

ROBOTICS

NEW ROBOTS BY SOVIET, CEMA MANUFACTURERS DESCRIBED

Moscow MATERIALNO-TEKHNICHESKIYE SNABZHENIYE in Russian No 6, Jun 85 pp 64-67

[Article by L. Eygel, junior scientific worker of VINITI [All-Union Institute of Scientific and Technical Information] of AN SSSR [USSR Academy of Sciences] and GKNT [State Committee for Science and Technology] (Moscow): "Industrial Robots Are in Warehousing"]

> [Text] Right now integrated mechanization and automation of production processes are being introduced widely and worker manpower engaged in manual labor is being reduced steadily, especially in auxiliary operations. Means for programed positional control, which are called industrial robots, are being applied to loading, unloading and warehouse transporting operations.

There are four generations of robots: the rigidly programed, those with replaceable programing, adaptive, and "intelligent." The international organization for standards defines the robot as a machine that forms a mechanism with several degrees of freedom and that often looks like one or several arms, which terminate with a grip, capable of holding a load. The system that controls it should have a memory, and sometimes it can use means of sensitization and adaptation, which allow the situation and the state of the environment to be considered. Such multiple-purpose machines ordinarily perform repetitive operations but can be adapted for other functions.

Industrial robots consist of mechanical organs, with drives, for grasping and movement in space. They are computer controlled and have a set of means for linking the human operator with the robot (the introduction of commands, and so on) and sensors for determining the positions in the external environment of the mechanisms which form the positional-control system, by means of which various control programs are switched on at the necessary points and the functioning of objects is monitored.

Position-program control is characteristic for modern first-generation robots, which do not have devices of the human sensory-organ type. They operate under fixed programs which are written on magnetic tape or drums and are connected up by the positional-control sensors.

Our country attributes great importance to the development, manufacture and introduction of manipulators and robots. Basically, ENIMS [Experimental

Scientific-Research Institute for Metal-Cutting Machine Tools], Orgstankinprom [State Industrial-Design and Experimental Institute for Organization of the Machine-Tool and Toolmaking Industry], VNIIPTmash [All-Union Scientific-Research and Design-Development Institute for Elevating and Conveying Machinebuilding, Loading, Unloading and Warehouse Equipment, and Containers], and other organizations are engaged in designing them. By the end of the current five-year plan period alone, about 45,000 robots will be in use in the economy. Model UM-1, Universal-5, Sprut, Sport and other industrial robots and manipulators are being manufactured.

The Sprut system consists of two manipulators that are moved on monorail tracks and bring blanks that weigh up to 250 kg from the warehouse to the machining site. The manipulators move at a rate of 30 meters per minute and they lift and lower loads at a rate of 16 meters per minute. The mechanisms are controlled from a panel.

The Kazan Order of Lenin Motorbuilding Production Association has developed a model LK-20 robot-manipulator, which is designed for moving loads to warehouses and departments. It is equipped with a program-control system. The MAK-1-50 manipulators with load-lifting capacity of 50 kg and MAK-2-320's with load-lifting capacity of 320 kg were created by VNIIPTmash. They were designed for loading containers and pallets, bringing blanks to the loading positions of industrial equipment (the MAK-1) and automating the loading and unloading of the carriages of overhead load-carrying conveyors (the MAK-2).

The Mosprommekhanizatsiya Production Association and the Aleksandrskiy Electrical Machinery Plant imeni 25th CPSU Congress are producing ShBM-150 model manipulators. The various versions of this manipulator, using the standard-design head, enable transfer operations to be performed under practically any industrial-enterprise production conditions (in warehouses, departments, and so on). The annual economic benefit from introducing one manipulator is more than 8,000 rubles.

The merits of the general-purpose manipulator designed by the central scientific-research institute Elektronika provides high operating indicators, a wide servicing area, and the availability of two vertical-motion speeds. This manipulator is designed for the mechanization of loading and unloading at warehouses and in assembling, mechanical and other departments. The annual economic benefit from introducing one manipulator is 2,000 rubles.

In order to carry out the tasks of automating loading, unloading and warehousing, robotics modules and robot systems, among which the robotics module of Kirovskiy Zavod Production Association design should be noted, acquires a special role and importance. It was made on the basis of domestic, serially produced equipment.

The robot possesses six degrees of freedom and has a large manipulation range. Thus, motion of the grip is 1.7 meters along the horizontal and 1.5 meters along the vertical, and the turn angle of the plane of the "hand" is 200 degrees. The weight of the load being worked is up to 40 kg, while the robot itself weighs about 300 kg. It will be used at the blanks department warehouse of the Kirovskiy Zavod Production Association.

The second-generation MP-12T robot, with adaptive control, which is designed for automating loading, unloading and warehouse transporting operations, can be used without modification in various branches of the national economy, particularly where man's participation is undesirable or difficult. In contrast with the previously developed Sprut-1 robot, the new floor-model robot is equipped with a system of microprocessors for adaptive control, which has equipment developed for remote link-up with the operator.

The MP-12T consists of a mobile loading platform based on a 4-wheeled chassis, a manipulator and an electronic-equipment box. The design was created on the basis of mutually replaceable modules (for the manipulator elements, for platform motion and for following the guide). A sensor for following the guide, in the form of a light-reflecting tape, which determines the path of the robot's motion, is installed underneath the chassis. In the forward part of the mobile platform is a sensor for safety of motion, and on the platform's side is a sensor for supporting the movement operation and for object recognition. The load platform contains 10 compartments for installing packaging containers. They have numerical coded inserts, while the boxes are the simplest of readout devices, by means of which the on-board minicomputer receives information about the load's destination (the number on the insert corresponds with the number of the workplace for which the compartment is intended). Each manipulator element has a sensor for position and handling, and the grasping device is equipped with sensors for the presence of a load and for safety.

The Kirovskiy Zavod Production Association is now operating a robotics system which includes seven object identifiers and enables automatic filling of provisional warehouses. The use of one identifier allows the release of three people for a three-shift operation and increased reliability in the distribution of parts about warehouses. Operation has indicated high reliability of the system. It enables the receipt of current information about parts that are passing various points of the overhead pushing conveyor, which is necessary for constructing the automatic production control system. The cost of the shape-recognition system does not exceed 4,000 rubles.

In accordance with specific-purpose integrated scientific and technical programs for creating and introducing industrial robots, a regional robotization center was organized in Kiev. With a view to involving blue-collar workers, engineers, technicians and white-collar workers of organizations of the ministries who make up these centers, in creating robots and putting them into production and, based upon this, in raising the level of mechanization and in reducing the share of manual labor in difficult operations and in work performed under harmful conditions, Minpribor [Ministry of Instrument Making, Automation Equipment and Control Systems] has organized, jointly with the Central Committee of the Trade Union of Machinebuilding and Instrumentmaking Workers, a socialist competition for robotization of center collectives. Workers engaged directly in introducing and mastering robotics are concluding among themselves multilateral agreements for the year. These contain mutual commitments with an indication of the numbers of robots and manipulators introduced and the volume of operations and the number of industrial operations performed by the robots.

The agreement names specific deadlines for fulfilling the commitments for each item and the persons responsible for it. The interests of speeding up

the introduction of industrial robots into production requires that all associates take an active part in this matter and that they be motivated morally and materially to achieve the best results. It is to this end also that the whole socialist competition is aimed. Wide discussion of the results of the labor competition will enable the motivation and activeness of members of the collectives to be raised.

At present a considerable share of low-productivity manual labor goes into transferring the articles that have been produced and are numerous and small in size, or into packing them into packaging for further transport. With a view to increasing the productivity of these operations, reducing prime production costs, and releasing people, systems for placing and storing various small articles are being worked out on the basis of the use of industrial robots and standard pallets.

The AN SSSR scientific council on the problem, "Robots and Robotics Systems," has formulated the most important directions of robotics development. These include fundamental and applied research of the principles of constructing new, highly effective industrial robots, the wide integrated automation of industrial processes with the use of industrial robots and modern computer equipment constructed on a microprocessor base, the organization of series production of industrial robots that have been developed and the standardization thereof, and so on. The scientific council is paying great attention to collaboration with CEMA-member countries in the robot area.

The introduction of industrial robots into industry will enable a number of social problems to be solved. The program adopted by CEMA member countries, which also calls for work on robotization, will lead to the release of 400,000 workers. The basic task here is that of developing standardization and unification of industrial robots. At present 128 different models of industrial robots with program control are being operated in these countries. Specialized industrial-robot production centers that engage in the production of constructional modules are necessary. In many CEMA member countries, long-term programs for robotization have been adopted and scientific coordination centers created.

In the CSSR [Czechoslovak Socialist Republic], for example, long-range plans for robotizing industrial production are viewed in party and governmental organs as one of the necessary prerequisites for developing the national economy. A long-range program for developing robotics during the 6th, 7th and 8th five-year plan periods has been worked out. The program calls for the development and updating of a modularized series of industrial robots and manipulators, further improvement in the technical characteristics of robotics equipment, the development of new systems for controlling industrial robots and manipulators, and the creation of adaptive and "intelligent" robots.

The program defines the scale and spheres of collaboration of the CSSR with CEMA member countries in solving the contemplated tasks. Operations are being coordinated with the participation of the prime organization ROBOTESN The unified scientific and technical concept that CEMA-member countries developed at the USSR's initiative, which determines the overall strategy, forms the basis for the national robotization program.

In Bulgaria a robotized system of intrawarehouse transport developed by the Bulgarian-Hungarian society Intramash and Sofia's Institute of Electric Loaders and Lift Trucks is one of the recent achievements of Bulgarian elevating-and-conveying machinebuilding. It is called upon to solve a set of problems associated with raising labor productivity and the quality of loading, unloading and warehousing operations. The machines and equipment that comprise this system will enable the use of manual labor to be entirely precluded. Basically, it is used in warehousing where the shelving height is 18 meters. The system includes a distribution guide laid under the floor, along which robotized electric tractors and battery-operated trucks move in the required direction, and also a shelf stacking crane with a load-lifting capacity of a thousand kilograms and with DC electric drive, which is equipped with microprocessor control. Speed of the crane's motion is 125 meters per minute, and height of storing of the loads is 18 meters. An innovation in the technology of processing loads is the use of robotic electric-battery operated trucks. These are new, effective means for rationalizing horizontal transport while disposing of loads in warehouses. They have advantages over other internal transport systems.

The GDR has formed a Central Technical Committee on Robotics under the GDR's Technical Office. The committee's mission is to establish a creative atmosphere in the area of inventiveness in carrying out plans for developing science and technology. The GDR is now using more than 22,000 robotics systems. Use of the new technology can be expanded in close collaboration with researchers, blue-collar workers and engineers. The leading enterprise in the GDR in output of robotics products is the Berlin Machine-Toolmaking Plant, which is producing a wide range of industrial robots. Their use will enable the load factor of the basic industrial equipment to be raised. The 2M601 model industrial robot is used widely at warehouses of the GDR's printing industry. Since 1982, this robot has operated 86 shifts for a total of 650 hours. It freed tending personnel from doing heavy work on storing printing production.

For the current five-year plan our country calls for a qualitative change in the structure of the pool of mechanized and automated means for loading, unloading and warehouse transporting operations. It is planned to master the series production of new types of equipment, including general-purpose robots. Much attention is paid, in so doing, to training specialists in robotics. The correct training of personnel before and after industrial robots are installed is an important factor in using them economically. In particular, specialists should define and validate the desirable level of production-process automation, as well as the rational area of use of industrial robots, and work out designs for mechanisms and instruments that take their effective use into account.

The use of robots in industrial production has been growing intensely in recent years. As the range and potential of industrial robots expand, they are used increasingly to perform operations that are dangerous or harmful to man. At the same time, the appearance and use of robots have necessitated that steps be taken to provide safe working conditions for the personnel connected with their operation. Correct and effective work-safety measures will enable robots to be used without harm to people's health. For these purposes, robots are being equipped with the necessary safety devices.

Questions of the placement, use and servicing of robots which are resolvable by the work-safety engineer and the designer also are important. These individuals should examine and consider all possible potential hazards created by a robot of a given design under the specific conditions of its use. In analyzing the environment, it must be determined whether some robot or other can operate under given production conditions without creating a hazard for people.

During the current five-year plan the national economy will receive about 45,000 industrial robots. Their use in production processes will raise the shiftwork factor for equipment supplied with manipulators by 30-40 percent, enable about 100,000 people to be released tentatively and yield an economic benefit of almost 500 million rubles. A system of programs which incorporates All-Union, interindustry, branch and regional programs will provide a unified engineering policy in the area of creating automated manipulators and robots. Participating in fulfillment of the programs will be 265 organizations and 45 ministries. Of these, 20 are AN SSSR organizations, 210 are sector organizations. The realization of these programs is aimed at the development and introduction of highly effective automated manipulators and robots, including those with adaptive and remote control, based upon unified outfitted articles and modules.

The traditional means now used for the mechanization and automation of loading, unloading, transporting and warehousing operations and for creating flexible operating processes in warehousing do not provide fully for reducing worker manpower, especially manpower engaged in heavy and labor-intensive operations. Therefore, for a drastic solution to the questions of raising labor productivity, reducing the manpower engaged in loading, unloading, transporting and warehousing and creating flexible operating processes in warehousing, scientific research must be performed, during which the desirability will be established of using industrial robots at enterprises that deliver USSR Gossnab products but have not previously used the robots. Work on creating warehousing robots with a great range of loads should be continued and expanded. In so doing, comparison tests must be made under a unified methodology in order to identify optimal models and to adopt them for series production.

11409
CSO: 1823/227

ROBOTICS

ADVANCES IN ROBOT TECHNOLOGY

Alma-Ata NARODNOYE KHOZYAYSTVO KAZAKHSTANA in Russian No 3, Mar 85, pp 48-50

[Abstract] The use of industrial robots significantly accelerates technological processes, providing them with a clear rhythm and creating conditions for increased quality of products. At the beginning of 1984, enterprises in Kazakhstan were utilizing 247 robots and manipulators. By late 1984, the number had increased by an additional 164 units, and in 1985 at least 160 additional robots are to be put in use. Examples of the introduction of robots to specific plants are noted. Unfortunately there is not yet in Kazakhstan a republic scientific and technical program for robotization of industry, as is the case in the Ukraine. The time has come to formulate such a program for Kazakhstan before the end of the current five-year plan. All industrial enterprises should draw up lists and specifications for working locations to be automated by the use of robots.
[154-6508]

CSO: 1823/154

ROBOTICS

BRIEFS

MOGILEV'S ROBOTS USED WIDELY--Belorussian SSR--Mogilev's Tekhnopribor Plant is well known as the largest supplier of industrial robots, which are endowed with great industrial potential. Among the enterprise's innovations is the Tur-10--a general-purpose industrial robot with a load-lifting capacity of 10 kg. The Tur-10 loads, unloads, welds, assembles and dresses burrs. Mogilev robots are operating successfully at enterprises and scientific-research institutes in flexible automated production. [Text] [Moscow EKONOMICHESKAYA GAZETA in Russian No 8, Feb 85 p 7] 11409

ROBOT LATHES SHAFTS AUTOMATICALLY--Minsk, 23 Jan--A robotics complex designed for turning flexible shafts and crankshafts automatically has been introduced at the forgings and blanks department of the Machine-Toolmaking Plant imeni S. M. Kirov. It will enable labor productivity to be raised and the labor-intensiveness of manufacturing shafts to be reduced. [Text] [Moscow PRAVDA in Russian 24 Jan 85 p 1] 11409

ROBOT SERVES SEVERAL MACHINES--Nalchik--The Telemekhanika Association has started to produce an installation for programed control of robots. A machine tool has a robot--that is nothing new. And the role of a machine that frees man from heavy, monotonous work also apparently is ordinary. But how do you get a robot to tend several machine tools at once? It is possible now. The Kontur electronic brain predetermines the "mechanical workers" program. And this year Nalchik will produce hundreds of copies of the Kontur-1. [Text] [Special correspondent A. Kazikhanov] [Moscow IZVESTIYA in Russian 3 Feb 85 p 1] 11409

AZERBAIJAN'S HEAVY-DUTY WELDER--Baku--Not so long ago a dead salt lake with stunted vegetation on its shores lay here. Nowadays the production buildings of an electrical welding-equipment plant that has been turned over for operation by construction workers from Trust No 4 of Azerbaijan SSR Minpromstroy [Ministry of Industrial Construction] tower up in its place. The plant, which is the prime enterprise of Azerelektroterm Association, has already started to make its first automated lines for arc welding, which are capable of overcoming the resistance of metal of any thickness. It should be noted that presently existing lines are intended for resistance welding only of thin metal. The new line, which will be shipped to the Rostselmash Plant, is tended not by welders but by robots, which will perform various operations. [Text] [T. Grigalashvili] [Moscow STROITELNAYA GAZETA in Russian 20 Feb 85 p 2] 11409

NEW GEORGIAN ROBOTS PRODUCED--Georgia today is receiving not only robots and other robotics products from various cities of the Soviet Union but it is itself also undertaking their manufacture. The Analitpribor and Elva science and production associations have manufactured a first lot of industrial robots--new general-purpose means for the integrated automation of production processes. Robotics complexes of these associations are being demonstrated at the VDNKh SSSR [USSR Exhibition of Achievements of the National Economy] and the Georgian SSR VDNKh. [Text] [Tbilisi ZARYA VOSTOKA in Russian 15 Jun 85 p 2] 11409

KHARKOV ROBOTS SERVE GRINDERS--Kharkov--A robot created by Kharkov Polytechnical Institute scientists in collaboration with specialists of the local Machine-Toolmaking Plant imeni I. V. Kosnor is capable of serving NC grinding machine tools. Such devices, which are elements of flexible automated production, have begun to operate at enterprises. [Text] [Kishinev SOVETSKAYA MOLDAVIYA in Russian 24 Jul 85 p 1] 11409

TELEVISION PATTERN-RECOGNITION ROBOT--A new manipulator which has passed its tests in the Central Institute of Robotics and Industrial Cybernetics possesses 100-percent vision, reports LenTASS [Leningrad Section of TASS]. It is equipped with a television camera which enables the mechanical helper to be oriented in space. Let various parts be scattered at random over the floor and the iron hand will, with precision, draw out first one, then another, of them and carry it to the needed place. The camera's eye records the position of these parts and then the information obtained from it is processed by a computer, which also helps to find the object. Specialists consider that in time the manipulators will get more organs of perception than man has: X-ray vision and ultrasound sonar. The new items designed by TsNIIRTK [Central Scientific-Research Institute for Robotics and Industrial Cybernetics] have already been given, for example, a sense of touch. [Text] [Leningrad LENINGRADSKAYA PRAVDA in Russian 25 Jun 85 p 1] 11409

CSO: 1823/220

PROCESS CONTROLS AND AUTOMATION ELECTRONICS

UDC:621.9.02.004.624:534.2

ACTIVE MONITORING OF TOOL WEAR BY ACOUSTICAL EMISSIONS

Moscow VESTNIK MASHINOSTROYENIYA in Russian No 4, Apr 85, pp 14-19

PODURAYEV, V.N., Doctor of Technical Sciences, BARZOV, A.A., Candidate of Technical Sciences and KIBAL'CHENKO, A.V., Candidate of Technical Sciences.

[Abstract] Studies have shown the need for combined studies of a combination of energy transformations which occur in the shape and structure formation zones of machine tools. Analysis of the energy parameters of the dynamic effects occurring in the cutting zone of a machine tool represent a new trend in the technology of working of metals. The acoustical emissions of a tool at work can be highly informative since they are actively related to processes of friction and wear of cutting tools, as well as the formation of quality parameters of the surface being worked. The most sensitive parameter of acoustical emissions to tool wear is the number of mode pulses, which increases with increasing tool wear, while the dispersion of the distribution decreases. Active monitoring of the wear of cutting tools on automated equipment means that as the cutting conditions change in accordance with the working program, the acoustical emission signal parameters also change; acoustical emissions therefore carry useful information for the control computer for use in real time control of the cutting process. This allows adaptive control of mechanical working processes.

Figures 9, references 5 Russian.
[159-6508]

CSO: 1823/159

TECHNOLOGY PLANNING AND MANAGEMENT AUTOMATION

UDC 621.9.06.-529:658.523

ADVANCES IN PRODUCTION AUTOMATION MANAGEMENT VIEWED

Moscow AVTOMOBILNAYA PROMYSHLENNOST in Russian No 10, Oct 84 pp 34-35

[Article by V. P. Nechayev: "The Current State and Developmental Prospects for Plant Technical Management Systems"]

[Text] One of the most effective and, in some cases, the only way to improve plant management at the present stage of scientific and technological development is the creation of plant technical management automation systems /ASU TP/ using on the computer. Which is understandable: modern technological processes are characterized by ever-faster pace and stiffer demands on precision of manufacture and quality of products.

ASU TP belong to the "man/machine" systems that carry out an automated data processing for the purpose of optimizing management decisions. As a rule, they consist of four parts: the object under control, which includes the primary and auxiliary technological equipment; the controlling system, including a control computer complex (with computers, communications to the object, operator consoles, data gathering and primary processing equipment) and its software; operator services (technicians/operators, troubleshooters, etc.); hardware and software services, for the formulation of control programs and maintaining all system elements in proper order. The ASU TP may control a single object (technological operation) or several technological processes (a sector or shop, such as a robot technical complex with direct computer control over a group of machine tools, robots, transportation, automated materials handling center). In the second case the systems, as a rule, are directly linked to the plant management automation system (ASUP) and may handle technical economic problems.

At least in theory. As for the specific functions of ASU TP even though dependent on the type and complexity of process under control, as well as the engineering capabilities of the management automation system itself, in the majority of cases they include: gathering and processing of information as to the state of the technological process and manufactured articles; monitoring and intensification of the process; logical program (optimal or complex-coordinated) control; analysis and prevention of emergency situations; technical diagnostics of individual parts and the overall system; calculation of the technical-economic indexes of the technological process.

There are three operating conditions of ASU TP i.e. three methods of interaction among the computer technology resources, the processes under control, and the human being: information advice, wherein the computer develops recommendations as to the conduct of the process and conveys them to the personnel; direct control, when the computer exerts direct control of the actuating elements; combination, wherein the computer adjusts the settings and the tuning parameters of the local regulatory systems. All this is done in a real time scale.

At present there are 42 ASU TP's in operation within our branch, in all the basic technological divisions, including the management of the GAZ truck assembly complex; management of assembly conveyors, materials handling centers, the body welding process, and the automated production lines for the VAZ engine cylinder blocks; the steel casting plant for the KamAZ; the testing of the engines in the VAZ, KamAZ, and YaMZ; the painting process for the UAZ and so on. In the 11th Five Year Period it is scheduled to introduce another 30 such systems, while in the 12th, 50.

The trend in the technical implementation of ASU TP at the branch factories may be illustrated by their introduction at the VAZ [Volga Automobile Plant] and ZIL [Likhachev Automobile Plant]: here the largest number of systems have been introduced in the assembly process, in the engine and part testing system, and in the materials handling section. This is no accident: these are the processes that have become the most automated and, consequently, suitable for introduction of management automation systems.

New prospects are offered by microprocessor techniques and the programmable controllers built from them. These exercise a program logic control, replacing the system of relay and semiconductor logic. The plant technical management system designed on this basis has the characteristics of self-diagnostics, improved dependability and maintainability, and can work with an executive management level in the interactive mode. The use of microcomputers and programmable controllers in plant technical management can implement the principles of distributed control within a multilevel hierarchical structure to suit the particular organizational characteristics. The new systems have a number of advantages over the previous ones based on a single central minicomputer: greater functional longevity; the option of introducing the system by parts, reducing the onetime capital investment, simplifying the delivery and setting up of the complete system, and shortening the payback time; easier programming (since the programs are allocated among the individual microcomputers and programmable controllers).

The introduction of ASU TP is certainly a very effective means of managing plant technology. But as a rule, such systems work by themselves. However experience shows that the solving of partial problems while maintaining the traditional technical and managerial level in other elements does not allow maximum utilization of the resources of the local systems. For this, it is necessary to create complex integrated management systems that simultaneously solve both problems of organizational/economic management and control of the

technological processes and plant. As an example of integrated systems we may mention the management systems for flexible automated manufacturing. In particular, one such system is a machine complex, comprising robotic program-retoolable machining, transport and materials handling equipment, unified by a common control system. This may be regarded as an automated technological complex, consisting of a robot technical machining complex (two or more modules), being the technological object of the control, and its controlling ASU TP. This version of ASU TP includes four subsystems: technological and engineering preparation of production, operations scheduling, records and dispatching control of the industrial process, and control of machine tools with numerical control (NC), entailing the sending of control programs to the machine tools, robots, and modules of the transportation and materials handling systems.

Our industry has developed a unified automation program on the basis of computer technology and microprocessor controls, covering all levels of production (ASUP, ASU TP, SAPR /computer aided design/) and plant technical management. The basic condition for its successful implementation (especially the ASU TP) is the use of prototypes to develop standard solutions suitable for copying. Such systems already exist today. For example, an ASUP /automated control system/ for the body welding complex of the VAZ-2108, built from programmable controllers and minicomputers, exercises control of the welding lines, intermediate materials handling stations, transport, collection and analysis of operational/dispatching information; an ASU for the melting in electric furnaces (casting plant of the KamAZ) on the basis of a minicomputer figures out the composition of the charge and the thermal balance of the melting process, compiles a schedule of operations for the melting furnaces and so on (the problem is solved in real time and comes down to the monitoring and regulation of the operation of the furnace transformer, the size of the current consumption, the lowering and raising of the electrodes and so forth). A distributed ASU for the automotive assembly conveyors at the VAZ is run by microcomputers (9 control systems for suspended pusher conveyors control 16 conveyors, synchronizing the movement of the main parts to certain stations of the welding lines in the sequence appropriate to the assembly of the automobiles); an ASU for the high storage racks at the ZIL and VAZ, also based on microcomputers and programmable controllers, enables processing of primary information, optimal search for shelf locations, sending of instructions to the actuating equipment, control of the machinery and diagnostics); an ASU to supervise the operation and predict malfunctions in the equipment of the casting plant of the KamAZ [Kama Automobile Plant] operates in real time (the computer receives signals from 3000 sensors); an ASU of a flexible manufacturing system for the machining of body parts at the NIIT-avtoprom [Scientific Research Institute for Automotive Technology] carries out the functions of control of the operation of the equipment (NC machine tools, transportation, materials handling, auxiliary equipment), translation of programs from the computer to the NC control unit, dispatching and scheduling.

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